ALOHA® Two Day Training Course
Outline of Instructor Manual

Day 1

I. Introductions (8:30 - 8:40 a.m.)

II. Introduction to ALOHA (8:40-9:25 a.m.)

III. ALOHA - Demonstrating a Scenario (9:25-10:00 a.m.)

BREAK (10:00-10:10 a.m.)

IV. Basics of Air Dispersion Modeling (10:10-11:40 a.m.)

V. File, Edit, and Site Data Selection Menu (11:40-12:10 p.m.)

LUNCH BREAK (12:10-1:00 p.m.)

VI. Setup Menu: Chemical and Atmospheric Submenus (1:00-2:00 p.m)

BREAK (2:00 - 2:15 p.m.)

VII. Setup Menu: Source Strength Submenu (2:15 - 3:30 p.m.)

VIII. Display Menu: Level of Concern and Display Results Submenus (3:30 - 4:30 p.m.)

IX. Hands On Running of ALOHA (4:30-4:45 p.m.)

X. Questions and Answers (4:45-5:00 p.m.)

Day 2

I. Short Reintroduction to ALOHA Model (8:30-8:35 a.m.)

II. Hands On Running of ALOHA (8:35-9:20 a.m.)

III Effects of Inputs on Outputs (9:20-9:40 a.m.)

IV. When and When Not to Use ALOHA (9:40-10:10 a.m.)

BREAK (10:10-10:25 a.m.)

V. Case Histories: Problem and Success Stories (10:25-11:10 a.m.)

VI. Tools and More Tips for Running ALOHA (11:10-11:55 a.m.)

LUNCH BREAK (11:55-1:10 p.m.)

VII. ALOHA Use for Mapping and Meeting Federal Requirements (1:10-2:10 p.m.)

BREAK (2:10-2:25 p.m.)

VIII. Examples: Class Exercises and Scavenger Hunt (2:25-3:25 p.m)

IX. Conclusion: MINI-Test and Wrap-up (3:25-4:10 p.m.)

Script Notes for Sessions I and II

Day 1

I. Introductions (8:30-8:40 a.m.)

- Trainers and class introduce themselves, discuss reasons for using ALOHA
- Trainers check class members' level of awareness/experience with ALOHA

II. Introduction to ALOHA® (8:40-9:25 a.m.)

Learning Objectives: Introduce ALOHA

- Give overview of course
- Explain what ALOHA is
- Describe what ALOHA can do and discuss footprint plot
    - ALOHA gives ballpark estimate, not exact answer
- Explain history of ALOHA and its uses: response, planning, intuition-building, other
- Describe users of ALOHA: responders, SERCs, LEPCs, universities, etc.
- Explain ALOHA as part of CAMEO
- Describe what ALOHA needs to run
- Explain about two platforms for ALOHA - Windows/Macintosh versions
    - Hard disk space requirements

Detailed Script for Sessions I and II · 1st Day

8:30 - 9:25 a.m. Sessions I and II Introduction to ALOHA

PowerPoint Slide #1

Welcome to the two-day training course on ALOHA. If there are goals to achieve in this course, it would be to become skilled in using ALOHA and to know when and when not to use ALOHA. The course should provide you with enough background so you can answer questions for local and state governments and others about the use of ALOHA.

Now I'm curious, with a show of hands, how many of you have heard of ALOHA?

How many of you have run the ALOHA model before or have some experience with ALOHA? For what purpose?

How many of you have taken some sort on previous course that discussed ALOHA such as at a CAMEO conference, or ALOHA course?

Well, this class covers the basics of ALOHA use. The course includes several parts. This morning, we will cover what is ALOHA, then demonstrate a release scenario, and finally provide you with a mini air dispersion modeling course. This afternoon will be a step by step instruction and hands on session. If time permits today, you will model an entire scenario on your own. Tomorrow will be mostly hands-on work. The course assumes you have familiarity with Windows or Macintosh operating systems.

Please feel free to ask any questions you have throughout the course. Do you have any questions so far?

PowerPoint Slide #2

Now that I have mentioned it several times already, what is ALOHA? ALOHA stands for the Areal Locations of Hazardous Atmospheres. It is a computer modeling tool for estimating the movement and dispersion of hazardous chemical releases. ALOHA can predict the rates at which chemical vapors may escape into the atmosphere from broken gas pipes, leaking tanks, and evaporating puddles. Then, it can predict how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release. A great advantage in using ALOHA is that it is easy to use and distributed widely.

PowerPoint Slide #3

What can ALOHA do? ALOHA can determine the furthest distance at which a person could experience an immediate serious health impact from exceeding certain concentrations of a toxic substance. This concentration is a level of concern, or LOC, at which health effects could occur. ALOHA can also be used to estimate the area where concentrations of a flammable gas may explode. ALOHA can be used to indicate the potential scale of the hazard involved in terms of impact distances in yards or miles. The model can be used to provide input on areas to set up vapor measurement or monitoring equipment. ALOHA uses the physical characteristics of the released chemical and the real-time circumstances of the release scenario to predict the dispersion of a hazardous gas cloud.

The user-friendly menu prompts you for details about the release. Using an extensive chemical library and release equations, ALOHA then solves the release problem rapidly and provides results in a graphic, easy-to-use format including plots of footprints and concentrations.

It's important to note that ALOHA provides estimates, not precise answers.

PowerPoint Slide #4

This is a footprint plot generated by ALOHA. How to interpret a footprint depends on what level of concern is being used. The footprint represents the area where the concentration of the chemical released is likely to exceed the LOC. If a flammable limit is used as the LOC, such as the lower explosive limit, then the footprint represents the area where gas concentrations are likely to become high enough to be flammable or explosive.

It is also important to note that the footprint does not represent the situation at any particular point in time. Instead, it represents the area where gas concentrations are predicted to exceed the LOC at some time after the release begins. Close to the release point, that would happen sooner than at points in the footprint farther from the release point. The Concentration graph can be used to see an estimate of how soon gas concentrations at a given location would rise above the LOC.

PowerPoint Slide #5

ALOHA can answer important questions in a relatively short time. For example, ALOHA could answer, What is the release rate forming the cloud?, what is the danger from the release of the chemical?, What areas downwind may be affected? However, it is important to note that ALOHA does not provide recommendations of action such as evacuation, but provides information that might help in making such decisions.

PowerPoint Slide #6

Now, how did ALOHA come about? The National Oceanic and Atmospheric Administration or NOAA noticed that fire departments and other response agencies did not have critical information about the chemicals or a toxic air dispersion model to predict threat areas. ALOHA was developed as a response tool in 1982. Over the years, several academic institutions and response organizations helped in its development and refinement. Its use by emergency responders increased as the benefits of its ease of use and speed of calculations were demonstrated. ALOHA first shipped with CAMEO in September 1986 to the Seattle Fire Department, and since late 1987 has been co-developed with EPA’s Chemical Emergency Preparedness and Prevention Office. In January 1991, a completely rewritten ALOHA was distributed. It included new algorithms to estimate source strength and to predict the dispersion of heavier-than-air gases. ALOHA continues to be refined.

ALOHA is an important tool to build intuition about the nature of the chemical accidents. In other words, by using ALOHA, the user can begin to get an intuitive idea of the relative atmospheric hazards of any random chemical by picking up facts about the chemical’s toxicity, properties, and ability to disperse downwind. The user can bring this experience to addressing a release in an actual incident. Intuition building is also an important component of developing a trained staff for emergency response.

PowerPoint Slide #7

ALOHA has value for many different types of users. As we described earlier, fire departments and other emergency responders assess a hazardous chemical situation and take actions including evacuation and sheltering-in-place. For example, several HAZMAT vehicles have a portable computer loaded with ALOHA. But what about emergency planning? State Emergency Response Commissions (SERCs) and Local Emergency Planning Committees (LEPCs) use ALOHA results in developing emergency planning documents under the Emergency Planning and Community Right-to-Know Act and in conducting a dialogue with facilities. Chemical companies may want to run ALOHA to evaluate possible scenarios, determine the priority of certain release prevention and mitigation strategies, and to even comply with certain regulatory requirements such as the EPA’s Risk Management Program Rule, which will be addressed in more detail later in this course. Finally, health care facilities and universities would be interested in ALOHA results. Universities and other training institutions use ALOHA as an instructional aid in teaching some of the basics of air dispersion modeling.

PowerPoint Slide #8

ALOHA can be run on its own or as part of a suite of three software applications that together are called CAMEO. For those of you who don't know, CAMEO stands for Computer-Aided Management of Emergency Operations. CAMEO helps emergency planners and first responders prepare for and more effectively deal with chemical accidents. Many local and state governments have CAMEO and therefore have access to ALOHA. Also, in the CAMEO system is a 'little' CAMEO application that consists of chemical information and planning database. MARPLOT is the mapping application, which allow users to look at resources in a local area as well as plot ALOHA footprints on area maps.

PowerPoint Slide #9

To use ALOHA, you will typically perform several basic steps. These include:
1) indicate the city where an accidental chemical release has occurred and the time and date of the accident.
2) specify a chemical of concern from ALOHA's library of chemical information
3) enter information about weather conditions / meteorological information

PowerPoint Slide #10

4) describe the source of the chemical release: direct, puddle, tank, or pipe;
5) choose the chemical concentration in the air at which there is a concern;
6) request ALOHA display a footprint. Again, a footprint shows an area where chemical concentrations in the air may meet or exceed the level of concern you have selected. ALOHA also has the capability to display this footprint on an electronic map of the city you selected. From the map you input or selected, you could see if any location such as a school or hospital is impacted by the release.

To run ALOHA, the user may not have all the input information and will have to make simplifying assumptions and estimates for some inputs. ALOHA has build in checks to make sure that some of these inputs are reasonable or consistent with other inputs. We will see examples of some of these ALOHA checks when we demonstrate and use the ALOHA model. ALOHA also has an extensive help system.

PowerPoint Slide #11

ALOHA is available on two platforms; Microsoft Windows and Apple Macintosh. ALOHA for Microsoft Windows requires Windows version 3.1, 95, or NT. Two and one half megabytes of space available on the hard drive is required. The Macintosh platform requires 2 megabytes of hard drive space; use a math co-processor or a Power PC because ALOHA will run faster.

Now, we are going to demonstrate ALOHA to briefly introduce you to running a scenario. You may not understand all the options presented and the choices made, but you will get a flavor of what ALOHA can do and recognize how ALOHA can be used. Don't worry, later on you will get plenty of hands on experience with the ALOHA model.

Script Notes for Session III

Day 1

III. ALOHA - Demonstrating a Scenario (9:25-10:00 a.m.)

Learning Objectives: Instructor quickly demonstrates ALOHA to initially introduce the students to running a scenario. After the demonstration, instructor points out that ALOHA is easy to run. The important thing is for students to learn what ALOHA does so it can be used properly.

- Explain reasons for demonstration
  - To show how easy it is to run and then to show graphics
- Read scenario of chlorine release at paper mill
  - Ask what is the downwind distance of the IDLH
- Run ALOHA using scenario inputs
  - *Click on the ALOHA icon and mention first window (about limitations)*
  - *Read each point in the window and state they will be discussed in detail later*
  - *Click OK and mention that the text summary window has key information about the release site*
- As screens appear, explain briefly
  - ALOHA menu bar: File, Edit, SiteData, SetUp, Display, Sharing
  - Choosing a location. *Go to SiteData and select Location. Type the letters of the city Columbia.*
  - Choosing a building. *Go to SiteData and select Building Type. Go over possible selections; select Enclosed Buildings for this example.*
  - Choosing a date and time. *For this example, select Constant time as January 15, 1996, 1:00 pm (enter 13 for military time).*
  - Choosing a chemical. *From SetUp, select chemical. Type CH and select Chlorine.*
  - Entering weather information. *From SetUp, select Atmospheric then User Input. Then enter Wind speed of 12 knots, 360 for Wind is from, Measurement height of 10 meters, Open country for ground roughness. Complete cover for Cloud cover, and then press OK. Then enter 70°F, D for stability class, no inversion, and humidity of 70%.*
  - Choosing a Source. *From SetUp, select Source. For this example, select Tank. Then select Vertical Cylinder with a diameter of 3 feet and length of 4 feet. In the next window, select Tank contains liquid and Chemical stored at ambient condition. Then, enter 1 ton as the mass of the tank. Next, enter 10 by 3 inch opening through a rectangular Hole. Finally, enter the leak as 6 inches above the bottom of the tank.*
  - Computational Preferences will not be discussed.
  - Choosing a Level of Concern and plotting a footprint. *From Display, select Options to open the Display Options window; use default values for Level of Concern. Select Footprint to display the dispersion cloud. Plot the footprint on MARPLOT.*
- Final points on ALOHA.
  - ALOHA gives ballpark estimates: there is a random component to dispersion, ALOHA has simplifying assumptions, and the user may guess at some inputs.
  - ALOHA is easy to use. Do not misuse or misinterpret ALOHA.

BREAK (10:00-10:10 a.m.)

<u>Detailed Script for Session III - 1st Day</u>

9:25-10:00 a.m. Session III — Reasons for Demonstration (1), Scenario (2), ALOHA Menu Bar and Selecting Inputs (3), & Final Points about ALOHA (4)

Learning Objective: In this section, instructor will introduce students to running ALOHA through demonstration of a sample scenario. This demonstration will illustrate how easy it is to use ALOHA. The goal is for student to learn what ALOHA can do and how to use it properly. As part of the demonstration, instructor shows student key output of ALOHA, the footprint, and how to interpret it.

1) Explain reasons for demonstration

a) Show how easy to run
b) Show graphics

2) Read following scenario of chlorine release at paper mill (two slides show inputs)

Powerpoint Slide 12
At a paper mill located in a highly industrialized area of Columbia, South Carolina, liquid chlorine is stored in several tanks. The chlorine is normally kept at ambient temperature. On January 15, 1996 at 1:00 pm, a reckless forklift operator punctures one of the tanks, and the liquid chlorine begins to spray out in a fine mist. The vertical tank is 3 feet in diameter and 4 feet high and holds 1 ton of chlorine. The forklift has made a 10-inch-by-3-inch hole about 6 inches above the bottom of the tank. The ground below the tank is unsurfaced soil.

Powerpoint Slide 13
At the time of the spill, the sky was completely overcast, the air temperature was 70^{o}F, and the wind was blowing from 360 degrees at 12 knots, measured at a height of 10 meters. Earlier in the day, there had been some rain but it had stopped before noon.

What is the downwind distance of the IDLH?

(2a) Run ALOHA using scenario inputs (use computer screens as overheads)

a*) Click on the ALOHA icon. Mention the first window that appears - Air Model Limitations. (For example, ALOHA does not deal with fire explosion hazard, terrain accounting, chemical solutions or mixtures, particulates).*
b) Read each point in the window. Mention will discuss in more detail later.
c) After pressing OK, mention that the text summary window displays key information about the release site.

3) ALOHA menu bar - just briefly go over what is in the menu

a) File - allows user to open, save, and print files.
b) Edit - allows editing of items in the Text window.
c) SiteData - has Location, Building Type, and Date & Time selections. These are used to enter site data.
d) SetUp - has Chemical, Atmosphere, Source, and Computational selections. Again, used for scenario data.
e) Display - window organizing and ALOHA output.
f) Sharing - deals with interfacing ALOHA with CAMEO or MARPLOT.

(3a) Choosing a Location - A first selection for the release conditions

a) First, go to SiteData on the menu bar.
b) Select location. A list will appear. Simply type the letters of the city you are interested in.
In this case, type CO, and then scroll down to and select Columbia, South Carolina.
c) Mention the Help selection here and throughout ALOHA data entry screens.

(3b) Choosing a Building

a) Again, within the SiteData menu, select Building Type. This is for buildings within the path of the cloud.
b) Go over the possible selections. Enclosed buildings can be selected for this case.

(3c) Choosing a Date & Time

a) Indicate that the Date & Time is related to weather and other conditions that affect dispersion.
b) Use the internal clock only when you are modeling a release occurring at or about the same date & time of the incident. The internal clock is the time clock kept by the computer.
c) For this case, select the Constant time as January 15, 1996, 1:00 pm.
d) Mention the hours go from 0-23. There is no am or pm. Hence, for pm hours, add 12; 1 pm becomes 13.

(3d) Choosing a Chemical

a) First, go to SetUp on the menu bar. Select Chemical. A list of chemicals will appear.
b) Simply type the letters of the chemical you are interested in.
c) In this case, type CH, and select Chlorine.

(3e) Entering Weather information

Weather conditions affect dispersion. ALOHA asks for weather information that is provided in the scenario.

a) Again, go to SetUp on the menu bar. Select Atmospheric then User Input, which allows user to provide information.

b) After selecting User Input, a window will appear.
c) Under Wind speed, enter 12 and select knots as the units and 360 for Wind is from.
d) Emphasize the importance of selecting proper units.
e) In this case, Measurement height above ground is 10 meters.
f) The ground area downwind of the tank is low cut grass, so select Open country for ground roughness.
g) The sky was completely overcast, so select Complete cover for Cloud cover.
h) Press OK and another window will appear.
i) Enter 70^{o}F, stability class, which we will discuss later is designated as D by ALOHA, select no inversion, and humidity is probably 70 percent given the rain earlier in the day.

(3f) Choosing a Source

a) Select Source from the SetUp menu. Mention there are options for Direct, Puddle, Tank, and Pipe release.
b) In this case, select Tank. A window will appear.
c) Select the Vertical Cylinder, then enter dimensions: 3 feet diameter, 4 feet length. The volume will then be automatically displayed.
d) Another window will appear. Select Tank contains liquid and Chemical stored at ambient temperature.
e) Another window appears. Enter the mass of the tank as 1 ton. As can be seen, liquid level is then displayed.
f) Another window appears. In this scenario, a rectangular opening is appropriate. Enter 10 by 3 inch opening through a Hole.
g) The final window then appears. The leak is about 6 inches above the bottom of the tank.

(3g) Choosing Computation Preferences

For now, we are going to skip over computational preferences.

(3h) Choosing a Level of Concern and plotting a footprint

a) Under the Display menu, go over the Options, Text Summary, and Footprint selections. Point out that the Text Summary window has appeared throughout the session.
b) Select Options to open the Display Options window. The Level of Concern is a particular established exposure to the chemical that results in specific immediate health impacts. In this case, the default values will be used.
c) Select Footprint to display the area where ALOHA predicts the concentration will rise above your level of concern.
d The shaded area shows where chlorine concentration is at or above the level of concern. The furthest impact distance is 1.8 miles.

(3i) Plotting on Map

a) Finally, indicate that the footprint can be plotted in MARPLOT. State that although MARPLOT is covered in another course, it will be shown to illustrate on of the connections between ALOHA and MARPLOT.
b) Click on Sharing Menu
c) Click on MARPLOT and go to Map
d) Click OK
e) Click Sharing and ALOHA and Set Source Point

4) Remember, ALOHA gives ballpark estimates, not exact values

Point out the following:

a) There is a random component to dispersion.
b) ALOHA makes simplifying assumptions.
c) The user may guess at some inputs like hole size.

(4a) Final important points

a) ALOHA is easy to use
b) Don't misuse or misinterpret
c) Suggested language below to make points a) and b)

Now you see how user-friendly it is to run the model. You yourself will be able to run the model easily. The important thing is to learn what the ALOHA model is doing, to know what is behind the model so you can use it properly. ALOHA should not be used for scenarios for which it was not designed. Also, ALOHA results should not be misinterpreted or misused. In some cases, lives could be a stake. ALOHA does have a built in warning system to try to guard against misuse but the user has the ultimate control. A large part of the remainder of this course is to teach you the skills and give you the knowledge to make decisions in using ALOHA.

Script Notes for Session IV

Day 1

IV. Basics of Air Dispersion Modeling (10:10-11:40 a.m.)

Learning Objectives: Understand the basics of air dispersion

- What is Air Dispersion?
  - Present visual picture of release of diborane
  - Indicate purpose of air dispersion
- Air Dispersion models
  - Types (users, complexity, costs)
  - Output describe extent of hazardous area
  - Uncertainties in modeling
- Two Kinds of Dispersion modeling: routine and accidental releases
  - Describe routine (examples)
  - Describe accidental releases (examples)
  - Discuss stages of accidental
- Five areas important for Accidental Modeling
  1) Meteorology and local conditions
     - Wind speed and direction
     - Atmospheric stability (connection with time of day, other things that affect)
     - Ground roughness
     - Inversion heights
     - Other: humidity
  2) Dispersion mechanisms (ALOHA selects type or you can choose)
     - Behaviour of neutrally buoyant gases (passive dispersion)
     - Behaviour of heavy gases (gravity slumping)
     - Relative impact
     - Which model to use
     - Gaussian model
     - Dense gas models
  3) Source strength
     - Instantaneous versus continuous
     - Non pressurized liquid discharge
     - Pressurized gas release
     - Pressurized liquid release (two-phase)
  4) Level of Concern
     - Level of Concerns (IDLH, ERPG)
     - Concentration and dose
  5) Interpreting data
     - Cautions
     - Most important in influencing dispersion

       (Atmospheric stability / wind speed / source strength / gas density)

Detailed Script for Session IV · 1st Day

10:00 - 11:40 a.m. Session IV Basics of Air Dispersion Modeling

PowerPoint Slide #14

The first thing we need to do to correctly operate ALOHA is to learn about air dispersion and air dispersion modeling. So get ready for a short 60 minute course on air dispersion modeling.

PowerPoint Slide #15

OK, imagine you are developing emergency plans for a facility and you must anticipate a release of diborane during a loading operation. The truck pulls up, makes the proper connections, and starts the pressure loading. But something goes wrong. The loading hose completely severs and pressurized gas rushes out and makes the hose appear like a agitated snake. Looking at the scene you imagine this cloud of brown smoke moving downwind. And what is it doing? As it moves downwind, it is becoming more voluminous, however it also appears less dark brown than at the severed end of the hose. The release cloud is being affected by a complex set of phenomena including wind speed and ground features. As a result, the release cloud is being moved and dispersed in both the downwind and crosswind directions. Also, the chemical itself has properties that may cause it to slump to the ground or possibly react with the air or humidity. This is what modelers say when they talk about air dispersion.

The only problem with this visual scenario is that diborane is actually a colorless gas. So none of what you have visualized thus far can actually be seen. If you were a responder, it certainly would be helpful to estimate the likely impact area of the cloud. Even if you could see the cloud, you wouldn't know what shade of brown cloud is toxic and which is not. That's where the air dispersion model comes in. Air dispersion models are tools for predicting the pollutant concentrations downwind from the source of a spill. Modeling allows users to visualize how a gas may move in the atmosphere.

PowerPoint Slide #16

Many types of air dispersion models exist - some are for research while others are for emergency response and planning. They range from simple equations that can be solved by hand, to complex models that require massive amounts of input data and powerful computers. Computer models have the advantage of being able to perform calculations quickly and store property information on hundreds if not 1000's of chemicals. As you might guess, costs for these air dispersion models vary widely. The type of model appropriate for a particular use depends on the scenario, the inputs available and outputs required, and the time and budget to operate the model and obtain results.

PowerPoint Slide #17

Often, the results will be numerical printouts of impact distances. Sometimes, the dispersion models produce a cloud map. Some people also call it a footprint, a vulnerable zone, an area of risk, or even the plume of doom. ALOHA calls it the footprint. The x-axis is the length of the cloud and the y-axis is the width of the cloud. The footprint is the area within which the ground-level concentration of a pollutant gas is predicted to exceed a specified level of concern concentration. In other words, if this were a footprint of a diborane release, the shaded area within the footprint could be greater than or equal to 40 parts per million, which is a level of concern for diborane.

Underlying this simple figure is a series of equations and assumptions that attempt to predict the complex chemical and physical interactions that are characteristic of a release and its subsequent dispersion. There are many uncertainties in air dispersion modeling. The release rate may not be known. Other uncertainties include the toxic concentration thresholds used, other inputs in addition to the release rate, and the dispersion behavior at large distances from the release source. Many researchers agree that a good model is one that can predict concentrations at various distances within a factor of two of concentrations measured in an actual spill test.

PowerPoint Slide #18

Two of the most common kinds of dispersion modeling are those used for routine emissions and those used for accidental releases. Early research in the air dispersion field focused on routine emissions. An example of routine emissions is the continuous release of sulfur dioxide from a plant smokestack. For this long term type of emission, you might be worried about global effects such as global warming or getting cancer after years of exposure. Typically, for this situation, the source strength is continuous and well defined. A simple dispersion model called a Gaussian model is most often used to describe the release behavior.

In contrast, most accidental releases involve a limited duration, acute release. Examples include a leaking valve on a chlorine cylinder, break on a tank car hose, and rupture of a relief valve due to tank overpressure. These releases are more associated with immediate health effects. For modeling accidental releases, the user must often guess important inputs such as the source term. Also, many accident scenarios that involve pressurized releases are not well understood and therefore may not be addressed well in many models. Traditional Gaussian models may be too simplistic for many emergency releases.

ALOHA is used to carry out accidental, non-routine release air dispersion modeling. More specifically, ALOHA is for short-term accidental releases involving hazardous materials but not radiological materials. The focus of this air dispersion modeling course is on accidental releases.

PowerPoint Slide #19

There are generally two stages of analysis of an accidental release and downwind dispersion:
(1) Estimating the source strength of the release
(2) Predicting dispersion behavior of the vapor cloud.

Estimating source strength is one stage but it may have several subparts. Here is an example of a vessel releasing chemicals that form a pool and then evaporate; in this example, estimating source strength would include determining the release rate out of the tank, the duration of release, and the evaporation rate into the air.

The second stage, dispersion behavior, depends primarily on the properties of the chemical cloud and the meteorology. Dispersion may also have several subparts as the vapor cloud rises or falls, and is diluted.

PowerPoint Slide #20

To effectively use any air dispersion model, you need to understand and examine the following 5 areas that influence the model use:

1) Meteorology and local conditions
2) Dispersion mechanism.
3) Source strength
4) Level of concern
5) Interpreting results

During the rest of this mini-course, I will briefly discuss these areas so as to introduce you to the movement and dispersion of gases.

PowerPoint Slide #21

Meteorology greatly influences dispersion. Most of what will be covered in this session on meteorology occurs in the lowest region of the atmosphere between the ground and 3000 meters. Air movements in the atmosphere can move, disperse, or trap a pollutant cloud. Let's examine a few of the meteorological and local conditions that influence dispersion or direction of the cloud. These include: wind speed, wind direction, atmospheric stability, ground roughness, and temperature inversions. Wind speed and atmospheric stability are the primary factors that influence dispersion. Atmospheric stability is a measure of the mixing or turbulence in the atmosphere, which in large part depends on the amount of solar radiation heating the atmosphere. I must caution beforehand, that many of the conditions in this slide are related to one another in complex relationships, but we will try to understand each one separately. The next seven or so slides are on wind and also prepare you for a further understanding of atmospheric stability.

PowerPoint Slide #22

Wind speed and direction affects how fast the pollutant cloud travels and where it will go. Wind is a complex phenomenon. Solar energy is the basic cause of wind. More solar energy strikes equatorial regions than the poles. Winds are set in motion as the heat moves to regions of less heat. The rotation of the earth also influences wind direction.

PowerPoint Slide #23

Zooming in a bit, wind is also formed because objects warm and cool at different rates. For example, continents warm and cool differently than oceans and the result is land and sea breezes. To understand this, consider that land is warmer than the sea during the day, while the sea is warmer at night. Because winds flow from cold to warm, sea breezes blow towards the land during the day and land breezes blow to the sea at night. As an example closer to home, consider that city sidewalks heat and cool differently than forest soils. This sets up hundreds of high and low pressure systems that cause wind.

PowerPoint Slide #24

Now, let's look how wind changes in the vertical direction. Wind speed changes with height in a pattern called a wind profile. Close to the ground, friction slows the wind. At higher elevations, the wind speed tends to be faster. Even higher, typically a few hundred meters or more, the wind speed reaches a maximum, because it is no longer affected by land friction.

PowerPoint Slide #25

In air dispersion modeling, you are more interested in local meteorological conditions. There are a few local variations in the wind that are worth discussing. One is called terrain steering. Terrain steering is the way in which land features modify patterns of air flow. Wind typically shifts speed and direction as it flows up or down slopes, around large hills and obstacles and along valleys, turning where terrain features turn. During the daytime, winds can flow up valleys because warm air rises. At night, air can cool and flow down slopes. These night winds descending down a slope are called drainage winds. At Bhopal, India, a drainage wind blew methyl isocyanate down into residential areas. In urban areas, wind flowing around large buildings forms eddies and changes direction and speed, significantly altering a cloud's shape and movement. In cities and towns, streets bordered by large buildings can generate a "street canyon" wind pattern that constrains and funnels a dispersing cloud. Most models - including ALOHA - cannot really account for terrain steering and wind shifts. Local variations in the wind are also caused by land and sea breezes as discussed earlier.

Because of all of these local effects on wind, wind speed and direction reports even from a nearby airport or weather service office may not reflect actual meteorological conditions at a specific site. In addition, the actual site conditions may not be the same conditions as the cloud travels downwind.

PowerPoint Slide #26

Dispersion of a chemical due to wind is also affected by mechanical turbulence. Mechanical turbulence comes from the drag that winds experience while passing along the ground surface or various surface obstacles such as forests.

PowerPoint Slide #27

A modeler should expect frequent changes in wind speed and direction. These wind speed changes and directions are complex and hard to predict. Therefore, ALOHA places limits on the ability to predict dispersion after about one hour. Another consideration in predicting where the cloud goes is its cloud meander. As we know, wind direction can change many times. Generally, wind direction is least predictable when the wind speed is low. For a release under low wind speed, the cloud could meander a lot and therefore, you will be unsure about the snakelike path that the cloud will take. Consequently, you will have to assume a greater area where the cloud could be.

PowerPoint Slide #28

This slide shows a footprint for a release under high and low wind speeds. The dashed lines indicate wind direction confidence lines. They encompass the area in which the gas cloud is 95% likely to remain, given expected amount of fluctuation in wind direction. For high wind speeds, the dashed lines will be close to the footprint because of the general lack of cloud meander. However, for low winds that are more subject to cloud meander, the area of the dashed lines may actually be a complete circle with the radius being the footprint length, indicating that the wind could shift and blow the cloud in <u>any</u> direction.

PowerPoint Slide #29

As you remember, atmospheric stability is a measure of the mixing or turbulence in the atmosphere. The degree of turbulence depends greatly on the amount of incoming solar radiation. During the daytime, the sun warms the ground. The warmed ground radiates warm, buoyant air which is caught below a layer of cooler air. The cool air wants to sink and the warm air wants to rise. This causes thermal turbulence and unstable conditions. In contrast, during the night, stable conditions often predominate. Through a phenomenon of conduction and convection, the air near the ground is cooled setting up a stable condition of warm air increasing by height.

PowerPoint Slide #30

How is atmospheric stability measured? Meteorologists have defined six atmospheric stability classes, named A through F each representing a different degree of turbulence in the atmosphere. Atmospheric turbulence is classified in terms of several factors including the amount of incoming solar radiation, time of day, wind speed, and cloud cover. The atmosphere is considered "unstable," or relatively turbulent when moderate to strong incoming solar radiation heats air near the ground, causing it to rise and generating large vertical eddies. Unstable conditions are associated with atmospheric stability classes A and B. Cool air near the surface has less of a tendency to rise and less turbulence develops. In this case, the atmosphere is considered "stable," or less turbulent, the wind is weak, and the stability class would be E or F. Stability classes D and C represent conditions of more neutral stability, or moderate turbulence. Neutral conditions are associated with relatively strong wind speeds and moderate solar radiation.

PowerPoint Slide #31

Here is a table with numerical cutoffs for determining stability class. The numbers were based on actual dispersion data. Because there is a lack of dispersion data beyond 10 kilometers, ALOHA does not generate modeling results past 10 kilometers. However, within this 10 kilometer range, how does atmospheric stability affect dispersion?

PowerPoint Slide #32

Under unstable conditions, a dispersing gas will mix more rapidly with the air around it, and be diluted most quickly to below-hazardous concentrations. Alternatively, the highest concentrations downwind tend to occur during stable conditions when the atmosphere is calm with low wind speeds and there is little turbulent mixing. In summary, a footprint will not extend as far downwind under unstable conditions as it would under more stable conditions. However, note that a footprint under unstable conditions will be fatter.

Like wind speed, stability can also be affected by local features. Typical weather patterns that are characteristic of deserts or rainy climates are associated with specific stability classes. In coastal regions, nighttime land breezes tend to offset the tendencies for nighttimes to be stable.

PowerPoint Slide #33

Friction between the ground and air passing over it is one of the factors that influence dispersion. Because the air nearest the ground is slowed the most, eddies develop, just as they would in the water next to a riverbank. The rougher the ground surface, the greater the ground roughness, and the greater the turbulence that develops. Surface or ground roughness depends on the size and number of the surface features on the terrain over which a cloud passes. The size of the surface features relates to the magnitude of ground roughness (in a complicated way), and when surface features are smaller, so is the ground roughness. For example, short grass may have a surface roughness of one centimeter and agricultural crops have a surface roughness of 20 centimeters. For gases that rise above the ground, surface roughness has limited effects. Alternatively, gas clouds that hug the ground will be more affected by surface features. Generally, the larger the roughness, the faster the cloud is dispersed. However, there is some controversy among modelers about using very large surface roughness factors because some modelers assert that large structures could actually channel the cloud rather than dispersing it. Many modelers handle this issue by using a general "rule of thumb" for dense gases: surface roughness factors that represent a large fraction of the cloud height should not be used. For example, a tall building should be considered an obstacle rather than a surface roughness element.

PowerPoint Slide #34

What is an inversion? and how might it affect dispersion distance?

On average, the temperature in the lower atmosphere decreases with height (or altitude) up into the atmosphere. This is the reason why mountains have a cooler climate compared to places at a lower altitude. However, some air masses may exhibit a reversal of this trend.

If the temperature of a layer of air increases with height, the condition is called an inversion. Because the term inversion refers to a layer of air, both a base and a top can be identified. The height of the inversion base (measured from the ground) is called the “Inversion Height.”

Why are we talking about inversions? What is their significance? The answer is that an inversion layer resists upward motion of air. This effect can be visualized by imagining that a rising parcel of air encounters an invisible barrier, similar to the ceiling of a room, and it cannot rise any further. The ceiling in the above example is its inversion base. An important implication is that a low-level inversion, with an inversion base near the ground, could trap a pollutant cloud close to the ground. This phenomenon - entrapment of the pollutant - could extend the impact distance compared to free dispersion of the pollutant in the absence of an inversion.

Where and when does an inversion occur? It occurs routinely during the night, the early morning before sunrise, and around sunset.

How do you know there is an inversion? Sea smoke and low ground fog are good indicators of this type of inversion.

A word of caution: A low-level inversion is different from an inversion with its base thousands of feet above the ground. The inversion found at a greater height is of little relevance to the dispersion of accidental gas releases; the thickness of the layers of air involved is far greater in comparison.

PowerPoint Slide #35

In ALOHA, there are two main categories of pollutant gases: neutrally buoyant gases and dense gases. ALOHA contains two dispersion models for predicting footprints for both of these gases. Neutrally buoyant gases are gases that have approximately the same density or molecular weight as air. Neutrally buoyant gases move along with the wind and disperse primarily by turbulence in the atmosphere. This is called passive dispersion.

In contrast, dense gases behave as gases that are heavier than air. When a dense gas disperses, it undergoes three different stages. The first stage is gravity spreading, essentially slumping to the ground because it is heavier than the surrounding air. In the second stage, the cloud remains flat and flows like water downstream. The last is the passive stage when the cloud becomes more diluted and its density approaches that of air, it begins behaving like a neutrally buoyant gas.

PowerPoint Slide #36

Neutrally buoyant gases move along with the wind and disperse primarily by turbulence in the atmosphere. This is called passive dispersion.

In contrast, dense gases behave as heavier than air gases. When a dense gas disperses, it undergoes three different stages. The first stage is gravity spreading, essentially slumping to the ground because it is heavier than the surrounding air. As the gas cloud moves, gravity makes it spread laterally. This can even cause some of the vapor to travel upwind of its release point. The second stage is called stratified shear flow where the cloud remains flat and flows like water downstream. The last is the passive stage farther downwind. As the cloud becomes more diluted and its density approaches that of air, it begins behaving like a neutrally buoyant gas. This takes place when the concentration of a heavy gas in the surrounding air drops below about 1 percent. For small releases, this last stage will occur in the first few yards. For large releases, this may happen much further downwind. Examples of gases that generally disperse as dense gases include chlorine, ethylene oxide, and phosgene.

So, I want to ask you a question. Which gas, the neutrally buoyant or the dense gas, will give more impact downwind? Assume for argument sake that the same quantity of neutrally buoyant and dense gases is released and they have the same toxic potency. [allow answers and ask for reasoning]. The answer is that the dense gas clouds will disperse more slowly than the neutrally buoyant cloud because the dense gas cloud initially hugs the ground and therefore exposes a smaller surface area of the cloud to dispersion by the surrounding air.

Early in the development of air dispersion models, models that dominated were those that estimated the dispersion of neutrally buoyant gases. However, prompted by a few serious releases of dense gases and an acknowledgment of the unique behavior of these gases, dense gas models with names like DEGADIS, SLAB, and HGSYSTEM emerged.

PowerPoint Slide #37

To use the correct model, you need to know if the release will form a dense or neutrally buoyant gas. Such a determination depends on the effective density of the chemical. Gases with similar density to air would be neutrally buoyant and gases heavier than air would be dense gases. However, there are some special cases where gases that you expect would be neutrally buoyant act as dense gases and vice versa. The temperature of the released gas makes a difference. Remember, colder gases will sink. Consider ammonia which is lighter than air. When released as a refrigerated gas, ammonia will behave as a dense gas. Some other gases that are lighter than air when not under pressure will, when released from a pressurized container, carry with them finely suspended liquid droplets called aerosols. The resulting overall density of gas and liquid droplets will be greater than air and therefore the gas and aerosol will demonstrate dense gas behavior.

There are also some cases where dense gases will act as neutrally buoyant gases. Even for heavier than air gases, if the release into the atmosphere is small, the overall density of the gas/air mixture may not be sufficiently greater than air to exhibit slumping. For example, a non-boiling puddle of a high molecular weight substance may not form a dense gas cloud because the puddle evaporation rate is low. To add to the complexity of the situation, note that the type of atmospheric stability could affect the likelihood of dense gas behavior. For example, very stable atmospheres such as F stability and low wind speed conditions tend to favor dense gas cloud formation because release concentrations are not dispersed quickly. Other factors may affect the behavior of the gas. Some models will consider some or all of these factors and make this determination of dense versus neutrally buoyant using various equations. ALOHA gives the user the option to select the dispersion model or have the computer automatically select the proper model.

PowerPoint Slide #38

The most common model used for neutrally buoyant gases is the Gaussian dispersion equation for continuous releases (ALOHA uses a modified form of this equation). According to this model, the cloud spreads out in both the crosswind and vertical direction as the wind carries it downwind. The concentrations in any crosswind slice of a moving pollutant cloud looks like a bell-shaped curve, high in the center where the concentration is highest and lower on the sides where the concentration is lower. As the pollutant cloud drifts farther downwind, it spreads out and the bell shape becomes wider and flatter. Concentrations depend only on release rate, wind speed, and atmospheric stability. The Gaussian model assumes the topography is flat and obstacle free, the wind speed and direction do not change, the source is continuous, and the pollutant does not deposit on the earth's surface (May be added - slide of assumptions).

PowerPoint Slide #39

There are many types of dense gas models available. Here is a listing of just a few. ALOHA dense gas model is based on the DEGADIS model. Remember that models have many uncertainties both in the equations and the inputs. For dense gas models, some uncertainties include the effects of large ground roughness, chemical reactivity, and deposition on the ground. In any case, dense gas models have gained increasing importance because dense gases tend to have higher concentrations downwind near ground level than neutrally buoyant clouds and therefore may pose a greater risk to human health.

PowerPoint Slide #40

Modelers often talk about "source strength." By that, they mean how much and how fast a pollutant gas is being released into the atmosphere. Source strength is probably the most important influence on impact distance, so it is important to obtain as accurate an estimate as possible. Chemicals can be stored as gases, liquids, mixtures of liquid and gas, or solids under various amounts of pressure and temperature. Consequently, a modeler should understand the physical and chemical properties of a released substance and its storage or process conditions because these largely determine the type and physical state of the release. The source term or release to the atmosphere is a required input for air dispersion modeling. Air dispersion models use different methodologies to calculate the source term. Generally, there are two ideal classes of sources. One is an instantaneous source, where the pollutant is released into the atmosphere all at once. An example is a container such as a chlorine cylinder that is dropped and splits open releasing all gas immediately. The other type of release is a continuous source, where the material is released at an approximately steady rate for a longer period of time. For example, material escapes as a gas through a slowly leaking valve. For modeling purposes, continuous releases last between 10 and 60 minutes.

Most real releases are somewhere between these types, meaning, they don't fit into a continuous or instantaneous release. However, they often can be approximated as one or the other. For example, a railcar accident where the track punctures a 3-foot hole in the vessel can be conservatively treated as instantaneous. Whereas, an evaporating puddle with a release rate that changes over time as the puddle spreads and cools should best be treated as continuous. Most air dispersion models try to address both situations. ALOHA can model instantaneous, intermediate, and continuous types of releases.

PowerPoint Slide #41

A chemical can escape into the atmosphere in many ways. Most accidental releases begin as a rupture, puncture, or valve leak on a tank or pipe. A chemical may escape into the environment as a gas, liquid, or pressurized mixture of gas and liquid which will be discussed later. In what form it will escape depends in large part on its boiling point and storage temperature. A gas will enter the atmosphere immediately; a liquid will form a pool and will then enter the atmosphere by evaporation.

PowerPoint Slide #42

Let's start with a non-pressurized liquid discharge. If the liquid is stored below its boiling point at ambient pressure, it will flow out of the tank as a liquid. A few factors that influence the release rate out of the tank include the head tank pressure and the hole size and jaggedness (ALOHA makes the

conservative assumption that the hole isn't very jagged). Then, the liquid will pool on the ground and evaporate into the atmosphere from the puddle surface. Many models include an algorithm or equations to determine the extent of pool spreading. Generally, flat ground is assumed. ALOHA assumes the spreading continues until a depth of 0.5 centimeters. However, a dike or other containment device may limit the spread of the pool. ALOHA can incorporate these if selected.
Generally, the evaporation rate depends on the vapor pressure of the liquid, the wind flow across the pool surface, and the pool surface area. Given a specific pool size and wind speed, the liquid pool will subsequently volatilize or evaporate into the atmosphere at a rate proportional to its vapor pressure. Vapor pressure is a measure of the propensity of the liquid to evaporate. For example, a spill of gasoline on a sidewalk will evaporate within a few minutes whereas a spill of mercury will not evaporate for weeks. The gasoline has a higher vapor pressure than mercury and so higher vapor pressure liquids will evaporate faster than lower vapor pressure liquids.

PowerPoint Slide #43

Now, let's discuss pressurized gas releases. When released to the atmosphere, a substance stored as a gas under pressure at ambient temperature will exit as a gas. The mass flow rate may be initially high depending on the size of the hole, but drops off as the pressure in the vessel drops. Thus, in the case of a gas that quickly exists through a large rupture or hole, a conservative choice is to assume that the release is instantaneous.

PowerPoint Slide #44

Two-phase releases involve the simultaneous escape of both liquid and gas into the air. Two-phase releases are the most complex and difficult to model. Some substances that are gases are stored under high enough pressures to liquefy them. The result is a liquid stored above its boiling point. It is more space efficient to store a liquid than a gas. For example, chlorine is a gas at normal pressures and temperatures, but is often stored under pressure as a liquid. Imagine a sudden loss of pressure caused by a leak in a tank of liquefied gas. The liquid, no longer pressurized, will boil violently because the chemical is stored above its boiling point. The tank contents will foam up and a mixture of gas and fine liquid droplets will escape through the hole in the tank as a two-phase mixture. An example is when a champagne bottle is opened, a mixture of gas and liquid droplets are released. The fine liquid droplets, called aerosols, will add significantly to the source strength or total mass released. A release of a two-phase mixture can be much greater in mass than release of pure gas or release from an evaporating liquid. Thus, a two phase mixture can significantly extend the hazard area. Estimating the amount of aerosol is an active research area. Some portion of the aerosol may rain out (fall out) of the vapor cloud near the release source. However, based on several experiments, it is possible to have no significant rainout of liquid from common liquefied gases such as ammonia and chlorine. Thus, ALOHA assumes that no rainout occurs.

PowerPoint Slide #45

The primary hazard from accidental releases of many toxic substances is inhalation exposure. To determine the potential health effects associated with inhalation of a chemical, you need to know the concentration of the chemical in the air and, usually, the amount of time an individual is exposed. A level of concern is a concentration and exposure time predicted to result in specific health impacts. These values are chemical-specific. To perform air dispersion modeling, a level of concern is needed as model input to generate areas where people may be at risk. There are many levels of concerns. Here are a few. The IDLH is immediately dangerous to life and health; the IDLH had a contact duration of 30 minutes, but now no longer has one as part of its definition. ERPG is Emergency Response Planning Guideline for a one-hour exposure. Levels of concern could give you an idea of the relative toxicity of chemicals. Most modelers and models determine the footprint area based simply on the concentration threshold only, rather than using the more complex dose value. Dose incorporates both concentration and exposure time. Modeling impacts by calculating a dose is a more accurate way of assessing hazard compared to a concentration, however, there is much uncertainty about dose measurement because most toxicological information on people is not well known. While we only briefly touch on this now, we will address this again when using ALOHA.

PowerPoint Slide #46

The inputs with greatest influence on the size of the footprint are: the source strength, atmospheric stability, level of concern, and whether the released chemical is a dense or neutrally buoyant gas. Thus, these should be well defined to improve the accuracy of the results. Also, when interpreting modeling results, you need to be cautious. First, make sure that you are appropriately using the model for the type of release. Become familiar with the limitations in using the model. Also, recognize that there are many uncertainties in the models and the inputs. In addition, the predicted area associated with the level of concern needs to be considered in the context of the extent of exposure by the affected population. Before focusing on one result from one set of assumptions, you should vary the inputs slightly to see how sensitive the results are to uncertainties in your inputs. Also, make use of your increased knowledge and intuition about modeling to evaluate the reasonability of your results.

Script Notes for Session V

Day 1

V. ALOHA File, Edit, and Site Data Selection Menu (11:40-12:10 p.m.)

Learning Objectives: Instructor demonstrates and students follow to learn about program icon, startup screen, help, file, and edit menu. Students will also gain a perspective on the relevant modeling issues regarding proper location, building type, and release date / time selections

- *Have students turn on machine and open ALOHA folder*
- Discuss program icon
- *Double Click on ALOHA dancer icon*
- Mention start-up screen and limitations, which will be explained more tomorrow
    - Low wind
    - Stable atmosphere
    - Wind shifts
    - Concentration patchiness
    - Fires
    - Particulates
    - Topography
- Discuss briefly file and edit menu
- *Click on file and edit*
- Discuss existence of text summary and built in ALOHA warnings and cautions
- Site Data menu
    - *Click on Site Data menu and note submenus*
- Location Submenu
    - Location and why important (show affect of different locations)
    - Selecting a location
    - *Click on site data menu and choose location*
    - *Search and click on Seattle*
    - Adding a U.S. city
    - *Click add and enter Gotham City*
    - *Add lattitude 40 26.4'N, longitude 74 7.2'W, 0 feet elevation, and state of New York*
    - Adding a location outside the U.S.
    - *Click on non-U.S. city*
    - *Enter Dublin, Ireland, 0 feet elevation, 53 20'N, 6 15'W, difference from Greenwich Mean Time of 0, and no daylight savings time*
    - *Click OK and then Select to add this location*
    - Mention about permanently adding / modifying
- Building Type Submenu
    - *Click on Site Data then select Building Type*
    - *Select single storied and discuss unsheltered vs. sheltered surroundings*
    - *Select unsheltered surroundings*
- Date & Time Submenu
    - *Select Data & Time from Site Data menu*
    - Explain internal clock and constant time
    - *Enter March 17, 1995 at 10:45 am*
    - *Enter 2500 hours and see what ALOHA does*
- Student Hands on Work
    - Read and enter scenario

LUNCH BREAK (12:10-1:00 p.m.)

Detailed Script for Session V - 1st Day

11:40-12:10 p.m. Session V Program Icon (1), Startup (2), File and Edit (3), & Site (4) Menu

During this session, instructor covers startup, file, edit, and site-selection menu.

Have students turn on machine and stop after opening ALOHA folder; make sure everyone is there.

1) Program icons

You will notice several program icons including ALOHA and CHEMMANAGER. We will eventually discuss briefly all of them, but for now

together please double click on the ALOHA dancer icon.

2) Start-up screen/Limitations

Now you will see the start-up screen. ALOHA cannot be more accurate than the information you give it to work with. But even when you provide the best input values possible, ALOHA, like other models, can be unreliable in certain situations, and it cannot model some types of releases at all.

ALOHA's results can be unreliable when the following conditions exist:

- very low wind speeds
- very stable atmospheric conditions
- wind shifts and terrain steering effects
- concentration patchiness, particularly near the spill source

ALOHA also doesn't account for the effects of:

- fires or chemical reactions
- particulates
- topography

We will discuss each of these in more detail tomorrow.

Help. Before we click on OK note the help button. Extensive help is provided via help buttons on many of ALOHA's screens. Please make use of them when using ALOHA. The help screens will remind you about the points mentioned in this training.

Important Instructions for Afternoon. For the remainder of this afternoon, I will first demonstrate and explain the features of ALOHA by going through the menus. After each main menu item, you will have a chance to work with the ALOHA program to build a scenario.

Generally, you will have designated hands on work every half hour or so. But for right now follow along with my ALOHA demonstration so you won't miss anything.

3) File and Edit

The first menu is File and the second menu is Edit. We are basically going to skip over these and get to the meat of running ALOHA.

click on file

But suffice it to say that ALOHA runs can be saved as a file and printed.

click on edit

The only command you can choose from the Edit menu is Copy. To copy text or pictures from an ALOHA screen, select the items, then choose Copy. You can then paste the copied material into a document in another application (such as a word-processing or graphics application).

Now, let us go to the data entry screens. Note that all of the data inputs and outputs for running an ALOHA scenario will be displayed in a text summary screen. Also, note that ALOHA will provide various caution, warning and stop messages to guide the user in the proper choice of inputs and proper use of the model. ALOHA provides different levels of warning. Some are information whereas others stop the process until other inputs are picked. For example, ALOHA has built in limits on some input parameters such as wind speed.

4) Site Data menu

click on the site data menu

Note that site data menu has three submenus, location, building type, and time and date.

(4a) Location Submenu Now, we choose a location or city and state for the release. Why choose a location? Well, ALOHA uses the latitude, longitude, elevation, and time zone of the location of a chemical release to estimate the sun angle and atmospheric pressure. ALOHA uses the sun angle to calculate the energy coming into a puddle. The more energy coming in, the higher the evaporation rate. The atmospheric pressure, which is determined by the elevation's location, will also influence the evaporation rate of a puddle and the dispersion of a gas cloud. The location information, for many cities where ALOHA users reside, is already included in ALOHA's location library, CityLib.

(*instructor demonstrate)*
1) To select a location, choose Location... from the Site Data menu.
2) Scroll through the list of cities. To speed your search, type the first one to several letters of the city name. For example, if I want Seattle, Washington, I begin to type SEAT quickly until Seattle Washington appears.
3) Then, click on the city name to highlight it, then click Select.

You can easily add descriptions of other locations that are not in ALOHA's location library. You can add both U.S. and non-U.S. locations. Do any of you think you will need to add a U.S. or non-U.S. location? OK. Later we will add a U.S. location.

(4b) Building type Submenu. The second menu item under Site Data is building type. Why does building type matter in a dispersion analysis? Maybe for emergency response purposes, you would like to know if the released chemical will infiltrate buildings that are in the release path and what the concentrations could be. Indoor infiltration is a function of leakiness of the building, the difference between outdoor and indoor temperatures, wind speed, and whether the building is sheltered or unsheltered. ALOHA will use this information to predict indoor infiltration rate and to estimate indoor concentrations at any building locations that you specify (it can also predict dose, if you can provide some toxicological information about the chemical of concern). ALOHA assumes typical North American buildings and that ALL DOORS AND WINDOWS ARE CLOSED. This will not be a conservative assumption on hot summer days. If building doors and windows are open, ALOHA will likely underpredict indoor concentrations.

You can specify either the type of building that is most common or of most concern to you in the area downwind of a chemical release.

> *(instructor demonstrate and students follow)*
> 1) For this example, assume the building of interest is a single-story school. *Click on single storied.* If you select a single storied or double storied building, you'll also need to indicate whether these buildings are in generally sheltered or unsheltered surroundings.
> 2) If buildings are surrounded by tall obstacles to wind flow, such as other buildings or trees, select Sheltered Surroundings. If there are no large obstacles, so that the wind blows directly onto buildings, select Unsheltered Surroundings.
> 3) *Select unsheltered and click ok.*

As an alternative to choosing a building type, you could choose an air exchange rate that is typical of buildings in that area. An air exchange rate is expressed as the number of exchanges per hour.

(4c) Date and time Submenu - Use this third menu option under Site Data to specify the date and time for ALOHA to use as the starting time of your scenario. What is so important about the time? The starting time of a scenario affects ALOHA calculations in two ways: (1) ALOHA uses the scenario start time to determine whether it is night or day when choosing a stability class; (2) ALOHA uses the position of the sun at the scenario start time to compute incoming solar radiation. Solar radiation can be an important influence on puddle evaporation.

You may choose either to enter a specific time, or to have ALOHA take the time from your computer's internal clock. Use a computer clock (as long as it is set right for the area) if you are modeling a real time release but be sure to set the incident TO THE LOCAL TIME where a release has occurred. For example, if you are running ALOHA for a real time incident in Miami but you are in Seattle, you should set the time to the current Miami time. Use a constant time option if you are attempting to compare various scenarios or to do post-mortem scenarios.

> *Instructor demonstrate and students follow -*
> 1) *From the Site Data menu, select Date & Time, click either:(a) Use Internal Clock - to use your computer's internal clock (this is ALOHA's default option) or...(b) Set Constant Time - to set a specific time.*

2) For constant time, type in the month, day, year, hour, and minute. ALOHA uses the 24-hour time system, in which time of day is indicated by four digits, the first two indicating the hour (00 to 23) and the last two indicating the number of minutes past that hour (00 to 59). Under this system, 6:00 a.m. is 0600, and 2:30 p.m. is 1430. *Enter March 17, 1995 at 10:45 am.*
3) What happens if you enter the nonsensical 2500 hours? Enter 2500 and note that ALOHA says to stop because inappropriate entry.

Student Hands on Work

Instructor should now show slide entitled 'Hands on Exercise (Site Data menu) and tell students to enter the data as the instructor enters the data.

PowerPoint Slide #47
On March 12, 1996 at 4:15 am, a chemical release occurred at a factory near Topeka, Kansas. An office building of concern was 1 mile away directly south of the factory.

Let's enter these together. First, click on the ALOHA icon. At the limitations screen, click on OK. (Wait until everyone is there) Now let's enter these data at the site data menu. (Walk through data entry).

After exercise, add U.S. location with students following.

Add U.S. Location *(instructor demonstrate)*
1) To add a U.S. City, choose location from the Site Data menu.
2) Click on Add to add a location.
3) Then, enter the location name, latitude and longitude, and elevation. Location name can contain up to 26 characters. ALOHA accepts a range of elevations from Mt. Everest to the Dead Sea. Latitudes must be between 0 degrees and 90 degrees; longitudes must be between 0 degrees and 180 degrees.

(Instructor demonstrate only)
1) As an example, I am entering Gotham City. Be as accurate as you can when entering elevation, latitude, and longitude. In this case, enter latitude of 40 26.4'N, longitude 74 7.2'W, and 0 feet elevation.
2) Then, click on the name of its state or territory in the scrolling list. To quicken the search, you can click anywhere within the list, and then type the first letter of the state. In this case, select New York.
3) Click OK. For states in multiple time zones, such as Indiana, you will be prompted to chose the appropriate time zone. You may also be asked to indicate whether to use standard time or daylight savings time for the location.
Add non-U.S. location only if time permits.

Add a non-U.S. location to the library *(Instructor demonstrate only)*
1) To add a non-U.S. location, select non-U.S. city. Enter the country name as well as the altitude and longitude/latitude. *For example, I will enter Dublin, an altitude of 100 feet, 53 20'N, 6 15'W.*
2) You also need to enter the country and the number of hours that local standard time at the location differs from Greenwich Mean Time. This time offset value should be positive if the location is in the western hemisphere like North and South America, and

negative if it's in the eastern hemisphere like Europe, Africa, and Asia. *For Ireland, the difference from Greenwich Mean Time is zero.*

3) You will also need to click the appropriate button to indicate whether standard or daylight savings time is currently in effect at this location. Ireland does not observe daylight savings time.

4) Once you have entered all necessary information about your new location, click OK.

5) Click Select to add the location to the library.

6) Click Cancel ONLY if you decide not to add the location to the library.

Ask the following two rhetorical questions:
If I am 10 feet off in elevation, will it make a big difference?
If I have a direct release, does sun angle matter?

Script Notes for Session VI

Day 1

VI. ALOHA Setup Menu: Chemical and Atmospheric Submenus (1:00-2:00 p.m.)

Learning Objectives: Instructor demonstrates and students follow to provide perspective on the relevant modeling issues regarding chemical, and weather selection to use and run the model properly.

- *Show both submenus from the SetUp menu and click on chemical to show list of chemicals*
- Chemical Selection
    - Chemical and why important (show affect of different chemicals)
    - Selecting a Chemical
    - *While still in chemical list, type AMM to select ammonia*
    - Chemical properties
    - *Go back to chemical and select hydrogen fluoride*
    - *Click on modify to display its boiling point to indicate it would be a liquid*
    - Adding a chemical
    - *Select chemical from the SetUp menu and click on add*
    - *Enter name of nasty stuff and molecular weight of 100*
    - *Click on OK and show nasty stuff is in the chemical list*

    How to permanently add or modify a chemical to the library
- Atmospheric Selection
    - *Click on atmospheric menu from the SetUp menu to show User Input/SAM option*
    - User Input
    - *Click on user input*
    - Wind speed, direction, and measurement height
        - *Type in 3 m/sec for wind speed and wind direction of NNE*
        - *Click on help to see that NNE is 22.5 degrees*
        - *Enter 3 meter measurement height*
    - Ground roughness
        - *Discuss and click on any type*
    - Cloud cover
        - *Click on 6 for a cloud cover of 6 tenths*
    - Air temperature
        - *Enter 50°F*
    - Stability class
        - *Discuss and click on A or B*
    - Inversion height
        - *Click no inversion height*
    - Humidity
        - *Enter medium humidity and review inputs*
  - SAM input, explain but don't work through
- Student Hands on Work
    - Read and enter scenario

BREAK (2:00 - 2:15 p.m.)

Detailed Script for Session VI - 1st Day

1:00-2:00 p.m. Session VI SetUp Menu: Chemical (1) And Atmospheric (2) Submenus

During this session, instructor covers the chemical and atmospheric submenus.

Instructor
1) show 1st and 2nd submenus in SetUp menu
2) click on chemical and stop; you should see list of chemicals
3) tell students they will get chance to enter information towards end of session

1) Chemical

Physical property and toxicological information for about 900 pure chemicals are included in the ALOHA library called ChemLib. The chemicals in ALOHA are those that represent potential air hazards. There may be more in CAMEO but they have been judged not to be a potential air hazard. ALOHA uses the information in the library to predict how a particular chemical may escape from a container and disperse in the atmosphere. Again, we come back to a screen that the chemical library does not include chemical mixtures or solutions; it also does not contain chemicals that have very low toxicity and are not very volatile. As you can see, you also have the capability to add or delete chemicals from the library or to modify information about the physical properties of any chemical. You can make either temporary or permanent changes to the library.

1a) Choose chemical -*Instructor!*
1) To choose a chemical from the SetUp menu, locate its name in the scrolling alphabetical index of ALOHA chemicals. To navigate quickly through the index, type in the first one to several letters of the name, then scroll up or down until you see the name of the chemical that you wish to select.
2) For example, if I am looking for ammonia, I will first type AMM to get down to ammonia.
3) Then, I can double-click on the name to select it. Alternatively, to select it, I could click once on the name, then click Select.

1b) Physical Properties - Now let's take a look at physical property data for the chemicals.

Instructor Demonstrate:
1) Go back to chemical
2) Click on modify to get to the property data. Many properties are listed. You can click on the name of the property and have the value displayed with units.

The values were obtained from two sources: one is called DIPPR database and the other is the chemical database in the CAMEO system. The properties determine whether the released substance will be a gas, liquid, or combination. For example, let's say the outside temperature is 50^{o}F or approximately 283 Kelvin. The boiling point of ammonia is far below this temperature so ammonia would be a gas. If we picked hydrogen fluoride, *move to hydrogen fluoride and click* *on modif y* its boiling point is 292 Kelvin, which is above 283 Kelvin so hydrogen fluoride would be a liquid under these conditions. Another important property data that we will talk about later is IDLH standing for Immediately Dangerous to Life or Health. This is a level of concern representing an exposure to airborne contaminants that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. For hydrogen fluoride, the IDLH is 30 parts per million. ALOHA's footprint represents the zone where the ground-level pollutant concentration may exceed a specified level of concern; you might choose to use the IDLH for a chemical as your level of concern.

Now lets add a chemical temporarily to the ALOHA database.

1c) Add - *Instructor demonstrates only:*

1) To temporarily add a chemical to the library, click Add

2) Enter the chemical's name and molecular weight. I add nasty stuff with a molecular weight of 100

As shown in your ALOHA manual, depending on the type of scenario that you wish to run, you may also need to enter particular chemical physical properties. <u>How do you know which data are needed to run the scenario</u>? The manual has a chart that tells you and selecting help in ALOHA also provides the data requirements. For instance, chemical name and molecular weight are sufficient to run a release where you know the release rate to air and you can use the Gaussian model. You will need additional values for other chemical properties to calculate release rates from Tank, Puddle, or Pipe or to run a dense gas dispersion. If you try to run a scenario, like a pipe scenario without the needed property information, ALOHA will display a note indicating that not enough chemical information is available.

click ok and nasty stuff is in the chemical list

1d) Permanent Change - Note that the changes discussed thus far will not be saved permanently in ALOHA's library. In other words, once you quit from ALOHA, the changes will be gone. To permanently add, modify or delete chemicals in the ALOHA chemical library, ChemLib, you need to use another program called ChemManager, which is outside of the ALOHA program. To use ChemManager, you must quit from ALOHA and double-click the ChemManager program icon. Because the changes you make with ChemManager are permanent, be sure to use care. You also may wish to back up your copy of ChemLib before you begin.

I will not demonstrate how to make permanent changes, but the way to modify or add a chemical is similar to the way we did it a couple of minutes ago. The minimum information that you'll need to permanently add a chemical to the library is its chemical name and molecular weight.

2) Atmospheric

The next SetUp menu is atmospheric conditions.

Instructor demonstrates:

1) Click on atmospheric menu, to show User Input/SAM option

In selecting atmospheric, you can enter information about current weather conditions into ALOHA either manually by typing in values for wind speed, air temperature, and other weather factors, or by connecting your computer to a portable meteorological station, called a Station for Atmospheric Measurement or SAM.

ALOHA uses the information that you enter to account for the main processes that move and disperse a pollutant cloud with the atmosphere. Let's start with the user inputs and come back to SAM option.

2a) User Input.

click on user input

The first of two user input screens asks for an assortment of information including wind speed, wind direction, ground roughness, and cloud cover.

Wind Speed and Direction - ALOHA needs to know the wind speed and direction as well as the height at which the wind speed and direction are measured. The wind direction determines what way a pollutant cloud will drift. The wind speed is important because it strongly affects both how fast the cloud will travel downwind as well as the shape of the cloud. ALOHA assumes that both wind speed and direction are CONSTANT throughout the area downwind of a chemical release. For this reason, use values that BEST REPRESENT CONDITIONS throughout this area.

Instructor:
1) Type in 3 meters/second for wind speed. Be sure to select appropriate units.

In the ALOHA manual or from the Help menu, you can check the "Estimating Wind Speed" section to see a table showing how to estimate wind speed from visual cues. For example, rustling leaves can indicate windspeeds of 1 to 2 meters per second.

2) Next, type in the wind direction.

This is the direction FROM which the wind is blowing. You can enter this information in either units of degrees true, or in one- to three-letter directional terms. For example, you can indicate that the wind is blowing from the north-northeast by entering NNE. This is equivalent to 22.5 degrees. If you were not sure what degree pertains to what direction, you could click on help to get your answer.

click on help. See NNE is 22.5 degrees.

Wind Speed Height - ALOHA also needs to know the approximate height at which the wind speed and direction are being measured, because it accounts for the way in which wind speed changes with height. Remember close to the ground, friction slows the wind. At higher elevations, the wind speed is faster. You have three options to indicate height:

Instructor:
1) Enter one of the three options for wind height. (i) The leftmost height choice is 3 meters, which is typical of a portable meteorological station. This is also ALOHA's default measurement height. (ii) The middle option is 10 meters, which represents the typical wind speed height used by many fixed weather stations. (iii) The rightmost option is provided if you know the height that your wind speed value is being measured at.

> *2) Enter a 3 meter wind speed height.* In ALOHA, wind speed must be greater than 1 meter per second at a reference height of 10 meters. Remember the limitation that ALOHA cannot model dispersion in very low wind speeds.

Ground Roughness - Before ALOHA can make footprint computations, you must indicate the roughness of the ground downwind of a release. Ground roughness is an important influence on footprint size. When all else is equal, rougher ground leads to more mixing and more dispersion. A footprint will be LARGER when you choose a SMALLER ground roughness value.

Choose either of two roughness classes to characterize the area downwind of a release, -- Open Country; or Urban or Forest. Alternatively you can enter your own value for "roughness length" used by meteorologists to describe ground roughness.

Examples of locations that would be classified as Urban or Forest include areas having many friction-generating "roughness elements", such as trees or small buildings. Open Country locations would include small obstacles, or few roughness elements in the area such as open fields or parking lots.

Choose the dominant category of ground roughness in the area where the pollutant cloud may travel. For example, if 70% of the area is urban or forest and 30% is open country, click Urban or Forest. If you can't easily determine the dominant category, run ALOHA once with each category selected to get an idea of the possible range in footprint size. If a roughness element (e.g., a tall building) is very large relative to the pollutant cloud, it may be an obstacle that diverts a pollutant cloud rather than a roughness element that generates turbulence. For example, in a downtown area on a Sunday morning with no cars on the streets, the best choice for a small release may be Open Country. In this case, the buildings are obstacles and the street is the "roughness" the pollutant cloud will experience.

If you prefer to type in a value for roughness length, you may wish to refer to the roughness length table in the ALOHA manual, which was also discussed in the air dispersion mini course. The standard unit for roughness is in centimeters, but you can enter it also in inches.

Cloud Cover - ALOHA needs a value for cloud cover, the proportion of the sky that is covered by clouds, in order to estimate the amount of incoming solar radiation at the time of an accidental release. Solar radiation is an important influence on puddle evaporation rate because heat from the sun can warm a puddle and speed up evaporation. Also, cloud cover affects atmospheric stability. In the U. S., cloud cover is usually measured in tenths: when the sky is completely covered by clouds, cloud cover is 10 tenths; when half the sky is covered by clouds, it is 5 tenths; when the sky is completely clear, it is 0 tenths.

> *Instructor demonstrate:*
> *1) Enter cloud cover in either of two ways: (i) click one of the buttons corresponding to 0, 3, 5, 7, or 10 tenths; or (ii) type a whole number between 0 and 10 into the data field for cloud cover in tenths For example, type 6 if cloud cover is 6 tenths*
> *2) Click OK*

Air Temperature - On the second entry page, ALOHA asks for the air temperature in the vicinity of an accidental release. Air temperature does not influence dispersion, but influences ALOHA's estimate of the evaporation rate from a puddle surface. The higher the air temperature, the more the puddle is warmed by the air above it, the higher is the liquid's vapor pressure, and the faster the substance evaporates. Air temperature is most significant in determining evaporation rate; to a much lesser extent it may be a factor in determining indoor infiltration rates. It is important to enter as accurate a temperature value as possible.

Instructor demonstrates:

1) *Enter 50 in the air temperature data field, then select degrees Fahrenheit*

Stability Class - Stability class has a big effect on ALOHA's prediction of footprint size. Once you have entered values for time of day, wind speed, and cloud cover, ALOHA automatically identifies which of six possible atmospheric stability classes - A, B, C, D, E, or F - are appropriate for the time and weather conditions that you indicate. Here the stability is C (assuming daytime, which hasn't been specified). The labels and buttons for inappropriate stability classes appear grayed-out indicating that they are unavailable for selection. If more than one stability class is appropriate for the conditions that you indicate, ALOHA generally selects the most stable of these classes. For example, if either A or B are appropriate, ALOHA selects B. However, you can click A if you prefer to use this class.

You also can click Override to override ALOHA's stability class choices and choose any of the six stability classes. You should do this, however, ONLY if you are sure that a special circumstance causes the best choice for stability class to be different from the choice(s) made by ALOHA. For example, the atmosphere over a large body of water or a snow-covered landscape sometimes may be more stable than would be expected for a given combination of wind speed, cloud cover, and time of day. If you are modeling a release over water, then, you sometimes might wish to choose a more stable class than ALOHA chooses for you. Also, E and F stability conditions normally exist only at night, but under some conditions may be appropriate choices for daytime stability class.

Inversion Height - Remember that an inversion is a phenomenon that could trap a pollutant cloud near the ground. Again, it is low-level inversions that are of concern in air modeling, not inversions that are many hundreds, or thousands, of feet up. ALOHA's Gaussian dispersion model accounts for inversions because the upward movement of the gas can be trapped in an inversion. ALOHA does not account for the effects of an inversion when it models a dense gas release.

Instructor show inversion buttons on screen. click no inversion.

If an inversion is present, type in the height of the inversion layer and select appropriate units. If there is no inversion, be sure that No Inversion is selected. The height of the inversion layer must be greater than 10 feet and no greater than 5,000 feet.

Humidity - ALOHA takes relative humidity into account when it estimates the rate of evaporation from a puddle and when it makes heavy gas dispersion computations. Considering the other meteorological inputs such as wind speed, humidity is not a critical input affecting the impact of the release. Relative humidity is defined as the ratio of the amount of water vapor that the air contains to the maximum amount of water vapor that it could hold at the ambient temperature and pressure. Relative humidity is expressed as a percentage. When relative humidity is 50%, the air contains one-half as much water vapor as it could potentially hold. The warmer the air, the greater its capacity to contain water vapor. Humidity affects the density of the air and therefore affects pool evaporation and the dispersion of dense gases.

Instructor:
1) Enter a relative humidity value in either of two ways: (i) click the button that best represents your relative humidity value; or (ii) enter the relative humidity (expressed as a percentage) in the humidity data field.
2) enter medium humidity
3) Review inputs thus far in text summary screen

2b) SAM

click back to atmosphere and select SAM station

Now that we have completed both the user input weather screens, let's look at the SAM weather data option. ALOHA can accept data from an external portable meteorological monitoring station, called a Station for Atmospheric Measurement (SAM). SAM data can be transmitted to ALOHA by either radio frequency or a cable. ALOHA can use SAM measurements of wind speed and direction, standard deviation of the wind direction, and air temperature. A few companies manufacture SAMs for use with ALOHA. A current vendor list is included in the student packet. You should check to make sure that any SAM you purchase transmits data in a format that ALOHA can accept. Check the section of the ALOHA manual on SAM stations to learn about ALOHA's requirements.

Instructor demonstrate:
1) ALOHA will prompt you to check that your SAM is set up and connected to the computer appropriately. Note ALOHA beeps with concern about release time (explain why happen)
2) Screen prompt for more information but I am going to cancel and leave details to ALOHA manual

Student Hands on Work

Instructor should now show slide entitled 'Hands on Exercise (SetUp menu) and tell students to enter the data as the instructor enters the data.

PowerPoint Slide #48
The chemical released at the Topeka factory was anhydrous ammonia. During the response effort, no on-scene weather observations were recorded. However, the investigation team collected observations from an airport 5 miles away from the accident. At the time of the accident, the wind was from the north at 5 knots. The air temperature was 22°F, the relative humidity was 58 percent and the estimated cloud cover was 1/10. (Walk through data entry)

2:00-2:15 p.m. BREAK

Script Notes for Session VII

Day 1

VII. ALOHA Setup Menu: Source Strength Submenu (2:15-3:30 p.m.)

Learning Objectives: Instructor demonstrates and students follow to learn about choosing a source.

Direct Source

- Describing a direct release
- *Select Source from the SetUp menu*
- *Select Direct and click on Continuous Source*
- *Enter 400 pounds/minute*
- ALOHA's duration limits
- *Select 30 minute duration*
- Source height
- *Enter 2 meter source height*
- Interpret an ALOHA footprint
- *From the Display menu, click on options to examine level of concern*
- *From the Display menu, click on footprint to calculate distance*
- Calculate Now
- Student hands on work (slide)

Puddle

- Entering information about a puddle
- *From the SetUp menu, select chemical and choose hydrogen fluoride*
- *From the SetUp menu, select source and then puddle*
- *Enter puddle area of 1,000 square feet and an average depth of 0.5 centimenters*
- *Enter default for soil type*
- Weather impacts and watch for changing weather conditions
  - *Enter ground temperature of 50^{o}F*
  - *For puddle temperature, select equals ambient air temperature*
  - *Select options from the Display menu and note IDLH, then click on footprint*
- Discuss footprint and note distance
  - *Run concentration graph for 1 mile from release*
  - Comment on graph
- Methyl chloride puddle
  - *Click methyl chloride and puddle*
  - *Explain ALOHA warning*
- Student hands on work (slide)

Script Notes for Session VII (Continued)

Tank

- Pressurized liquids and gases
- Tank size and shape

- *From the SetUp menu, choose source and then select tank*
- *Choose tank type and enter dimensions*

- Chemical state

- *Discuss the choices for this and the other selections that follow*

- Tank storage temperature
- Liquid in a tank
- Gas in a tank
- Hole in tank
- Leak height on tank
- Puddle formation
- Student hands on work (slide)

Pipe

- Types

- *Choose infinite reservoir*
- *Enter sample reservoir pressure*
- *Select unknown temperature*
- *For hole size, model assumes pipe sheared off so there is no need to enter value*

Detailed Script for Session VII - 1st Day

2:15-3:30 p.m. Session VII SetUp Menu: Source Strength Submenu

Click on source

In an ALOHA scenario, the source is the vessel or pool releasing a hazardous chemical into the atmosphere, and the source strength is the rate of release of the chemical into the air. A chemical may escape into the atmosphere very quickly as when a pressurized container is ruptured, or more slowly over a longer period of time, as when a puddle evaporates. ALOHA can model four types of sources. You need to choose direct, puddle, tank, or pipe sources. Choose direct when you know the rate at which a pollutant gas is entering directly into the atmosphere as well as the duration of the release. Choose puddle when the chemical has formed a liquid pool and is evaporating into the atmosphere. Choose tank when the chemical is escaping from a storage tank, either as a gas or as a pressurized or unpressurized liquid. Choose pipe when the chemical is pressurized gas escaping from a ruptured gas pipeline. During the session tommorrow, ALOHA's Decision Keys will be shown to illustrate the selection process.

After choosing one of the options, you will be asked to enter information on a series of screens. What sort of information do you think you would need for the pipe release, a tank release, a puddle, direct? (Instructor: Get students to identify) Once you click OK on the last screen, ALOHA will make its source strength calculations, and you'll be returned to the Text Summary Screen. You will see the results of the source calculations - predicted release duration, release rates, total amount released, and other information - in the text summary.

ALOHA places minimum and maximum limits on the duration of any release. ALOHA expects a release to continue for at least 1 minute, and it estimates source strength (release rate) for no more than 1 hour after a release begins. The reason for the 1-hour duration limit is that the wind is likely to change speed and switch directions during the release event. If you are responding to an incident, check whether release conditions change substantially before an hour has passed and perhaps update the footprint with new atmospheric and source information.

1) Direct
The direct source can be used if you know the amount of pollutant gas released directly into the atmosphere or if you have too little information about a release to use another source option but feel you can make a ballpark estimate of the source strength. (slide on direct). The amount that enters the atmosphere directly as a gas may not equal the amount spilled; for example, if a hazardous liquid has spilled, you will need to estimate its evaporation rate. When you use the Direct source option, you must first select the units for the amount of pollutant gas entering the atmosphere. You can choose either mass (i.e., pounds or kilograms) or volume (i.e., gallons or cubic meters) units. For our scenario, let's choose pounds.

1a) Continuous/Instantaneous Direct Release - When you choose the Direct source option, you must specify whether a chemical release is "continuous" or "instantaneous". A release is continuous when the chemical continues to escape for more than a minute or so (e.g., by evaporating from a puddle), and instantaneous when the chemical escapes into the atmosphere within a minute (as it would, for example, if a pressurized gas cylinder were to split open). ALOHA assumes that all instantaneous releases last for 1 minute.

Instructor demonstrates, while talking
1) Click Continuous Source to indicate the release type.
2) Enter 400 pounds/minute for the rate of pollutant entering the atmosphere. This must be either a rate, such as pounds per minute, for a continuous source, or a mass or volume quantity, such as pounds or gallons, for an instantaneous release.
3) *Choose the duration for your release as 30 minutes.* If the release is continuous but lasts for less than an hour, enter its duration in minutes. If the release lasts for at least an hour, don't change ALOHA's default value of 60 minutes. ALOHA cannot accept a value for release duration of greater than 1 hour, because weather conditions or other circumstances of a release are likely to change within an hour.

1b) Direct Source Height - The source height is the height of the location of a chemical release above the ground. Source height is zero if the chemical is released at ground level. In ALOHA, you can enter a source height greater than zero to model a release from an elevated source under two conditions:
(a) The first is that you are using the Direct source option. Other source options such as releases from puddles, tanks, and pipes are treated as ground-level releases, and
(b) The second condition is that the release is modeled as a Gaussian release. In other words, ALOHA considers elevated releases if the chemical disperses passively away from the release point. ALOHA will NOT model an elevated release if there is any substantial upward or downward movement of a gas cloud in the atmosphere. Upward movement could be a result of a heated or burning source and downward slumping may be characteristic of a dense gas.

Enter 2 meters for the source height. Note that ALOHA reminds you about height issue. Because ammonia is neutrally buoyant, we are fine, but if ALOHA were modeling ammonia as a dense gas, the height would be considered zero although the text summary would still say 2 meters.

2) Display Options-Level of Concern - Now we want to calculate a footprint. We first need to:
a) chooose display menu.
b) choose options submenu to examine level of concern. Note that the IDLH is just 1 possible level of concern and not necessarily the best; there is significant uncertainty associated with any toxic endpoint. Click to accept IDLH.
c) choose footprint to calculate distance.

Distance is 1200 yards.

<u>Student Hands on Work</u>

[Instructor should now show slide entitled ‘Hands on Exercise (SetUp menu)’ and tell students to enter the direct release data as the instructor enters the data. Then, briefly instructor and students look at options submenu under display menu to confirm level of concern. Then, run footprint and note distance. Select Concentration from the Display menu to determine the concentration directly downwind 1 mile from release at an office building. Input 1 mile for “Input X, the crosswind distance” and 0 for “Input Y, the crosswind distance.” The red line is the predicted outdoor concentration, while the purple dotted line is the predicted indoor concentration. Comment on graph and note where the concentration is below LOC.]

PowerPoint Slide #49

As part of the accident investigation at the Topeka factory, the fire department determines that 12,000 pounds of anhydrous ammonia were released in about 30 minutes from a leak at the bottom of a tank. The anhydrous ammonia was stored at ambient temperature.

What is the distance of the IDLH? Was the office building affected by the release? (Walk through data entry, display footprint and concentration graph)

2) Puddle

1) click on chemical to select hydrogen fluoride because as we remember, it is liquid at 50^{o}F
2) click on puddle under source menu

The second release option under the SetUp menu and Source submenu is the puddle. Remember the evaporation rate is dependent on the puddle's temperature (which is affected by solar radiation), the surface area of the puddle, the wind speed and the physical properties of the chemical. Some of this information is already entered under different parts of the ALOHA program. Also, to predict the time required to completely evaporate the puddle's contents, ALOHA must know the amount of liquid it contains.

2a) Area In the first puddle screen, you specify the area of the puddle (slide calculating area) If the puddle is roughly square or rectangular in shape, its area is equal to its length multiplied by its width. If it is roughly circular and you know its diameter, but not its area, divide the diameter in half to obtain the radius. Square the radius, then multiply this value by pi, 3.14, to obtain the area. If the diameter or the length and width are in units of feet, then the area will be in units of square feet.

Instructor demonstrate:
1) Enter a puddle area of 1000 square feet

2b) Quantity. You can specify the amount of liquid in the puddle by entering either: (a) volume, (b) average depth, or (c) mass (weight) of the liquid contained in the puddle. You will notice that the units change for each choice.

Instructor demonstrate:
1) Enter an average depth (0.5 centimeters). Note that this is lowest allowable value.

There are allowable inputs in ALOHA for all choices. ALOHA will indicate if you are not within acceptable values.

The next puddle input screen is soil type, and air and ground temperature.

2c) Soil Type For Puddle - Ground or soil type influences the amount of heat energy transferred from the ground to an evaporating puddle. Ground type is most important when the spilled liquid is "cryogenic." Cryogenic liquids are those such as liquefied natural gas (LNG), which are stored at low temperatures because they boil at temperatures well below ambient. As it computes heat transfer from ground to puddle, ALOHA assumes that the ground does not absorb any of the spilled chemical.

ALOHA offers you four choices for ground type:
(a) Default: unwetted soil not covered by rock or concrete
(b) Concrete: concrete, cement, asphalt, or otherwise paved surfaces
(c) Sandy: sandy, dry soil, and
(d) Moist: sandy, moist soil

ALOHA expects heat to be transferred most readily from default or concrete ground into a puddle, and least readily from sandy ground.

Instructor demonstrate:
1) Enter default for soil type.

2d) Ground Temperature For Puddle - ALOHA uses ground temperature to predict the amount of heat transferred from the ground to an evaporating puddle. The warmer the ground, the warmer the puddle, and the higher the evaporation rate. Your value for ground temperature should be the temperature of the ground below the surface, rather than at the surface. If you do not know the ground temperature, you can choose to guess that it is about equal to the air temperature. However, be aware that air and ground temperatures can be very different in some situations, such as in a parking lot on a hot day in the afternoon or on a street during the early morning after a very cold night.

Instructor demonstrates while talking
1) Type in for ground temperature 50 degrees Fahrenheit. Click Use Air Temperature if ground temperature is unknown.

2e) Initial Temperature For Puddle - Lastly, ALOHA must know the initial temperature of the puddle to predict the rate of evaporation from a puddle of spilled liquid. It assumes the initial temperature to be the same throughout the depth and width of the puddle.

You have the choice of either (a) use the ground temperature, or (b) use air temperature, or (c) enter a value for the initial puddle temperature. For simplicity, let's click the button that represents equal to air temperature.

Instructor demonstrate:
1) Select Use Air Temperature.

If your value for initial puddle temperature is above the liquid's normal boiling point, ALOHA will alert you and then set the initial puddle temperature to the boiling point. ALOHA assumes that a boiling puddle will quickly cool to its boiling point.

1) click on options and note hydrogen fluoride IDLH is 30 ppm
2) click on footprint

Note footprint. Distance is about 900 yards/850 meters and the footprint is narrow. The narrow footprint is a result of the wind speed and stability class chosen.

<u>Student Hands on Work</u>

[Instructor should now show slide entitled 'Hands on Exercise (SetUp menu) and tell students to enter the puddle release data as the instructor enters the data. Then, briefly instructor and students look at options submenu under display menu to confirm level of concern. Then, run footprint and note distance. Further run concentration graph for location 1 mile from release (office building). Comment on graph.]

PowerPoint Slide #50

For the puddle example, lets use hydrogen fluoride because it is a liquid at this temperature. Assume that the release occurred at a refinery in Topeka with the same location and atmospheric conditions as before. The hydrogen fluoride forms a puddle with the surface area of 1,000 square feet and a depth of 0.25 inches.

What is the distance of the IDLH? Was the office building affected by the release?

Ask <u>What would happen if we tried a puddle of methyl chloride?</u>

click methyl chloride
click puddle with same assumptions

Note ALOHA is beeping with an information concern that the temperature is higher than methyl chloride's boiling point. ALOHA will not model a chemical at something higher than its boiling point under normal atmospheric pressure.

3) Tank Option
The third release option under the SetUp menu and Source submenu is the tank release. ALOHA's Tank source option is to model the release of a pressurized or unpressurized liquid or gas from a storage vessel. If the tank contains a pressurized gas or liquid, ALOHA estimates the change over time in pressure and temperature inside the tank as it leaks. If the tank contains an unpressurized liquid, ALOHA assumes that gravity will drain the tank and a puddle will form on the ground.

3a) Tank Shape - To use this option, you must indicate both the size of the tank and its general shape.

> *Instructor demonstrate while talking:*
> *1) Choose the most appropriate of three tank types: (i) a horizontal cylinder, (ii) an upright cylinder, or (iii) a sphere. Choose horizontal cylinder.*
> 2) *Enter the tanks dimensions. For the cylinder, enter any two of the following three values: diameter, length, and/or volume.* If it were a sphere, you would enter either the tank's diameter or its volume. ALOHA will compute and display values for the remaining dimensions. "Volume" means the total volume of the tank, rather than the volume of chemical within the tank.
> [A 10 ft. by 25 ft. tank to be added]

3b) Chemical State in Tank - Whenever you model the release of a chemical from a tank, you'll need to specify the state of the chemical in the tank. ALOHA needs to know whether the chemical is a liquid or gas in order to estimate the quantity of chemical in the tank, and the way in which the chemical may escape from the tank as a pure gas, or as a pressurized or unpressurized liquid.

> *Instructor demonstrates while talking:*
> *Choose from the following three options: (i) Choose Tank Contains Liquid if there is any liquid in the tank, even if it's just a small amount, (ii) Choose Tank Contains Gas Only if there is no liquid present, or (iii) Choose Unknown if you don't know the chemical's state. In this case, click on liquid.*

If you are unsure whether a chemical in a tank is a gas or liquid, you will need a value for the total mass (weight) of chemical in the tank in order to run ALOHA and you will need to know the temperature in the tank. ALOHA uses this information, along with the chemical's properties to predict the chemical's state and the amount of chemical that could be released.

3c) Tank Storage Temperature - You next need to specify the storage temperature of a chemical within a tank. This helps the pressure within the tank and the rate at which the chemical will escape from the tank once the tank is ruptured. In cases when you don't know the chemical's physical state (gas, liquid, or solid), ALOHA uses this temperature to predict the state.

Instructor demonstrates while talking:

Choose from the following two options: (i) click Chemical Stored At Ambient Temperature if the chemical is stored at the temperature of the surrounding air. (Remember, you entered a value for air temperature when you entered atmospheric information), or (ii) if the tank is at a *different temperature, enter the storage temperature in the tank temperature data field, and indicate its units. Click on the ambient temperature option.*

ALOHA will alert you if your value for storage temperature exceeds both the chemical's boiling point and the ambient air temperature, but it will not prevent you from proceeding.

Remember the discussion earlier on substances stored above their boiling point and the potential for two phase release. Well, you may have a case where you know that tank temperature is near the boiling point, but not be sure whether it is above or below the boiling point. If this is the case, try running your scenario twice - first with tank temperature set to just below boiling, and again with temperature set just above boiling. Compare the two sets of results produced by ALOHA to find the range of release rates possible for your scenario. Running a liquid scenario at a temperature above boiling will give you the highest release rate and largest footprint, since in such cases ALOHA knows that the liquid will be pressurized, so it predicts a two-phase release.

3d) Liquid in Tank - Whenever you indicate to ALOHA that a tank contains liquid, you will need to identify the amount of chemical in the tank in one of four ways.

> *Instructor demonstrates methods of indicating liquid volume:*
> *(i) You can enter a value for the mass of the chemical in the tank. This should be the total mass of the liquid and its vapor in the tank. (ii) You can enter a value for the volume of the liquid in the tank. One way is to directly input a volume number with the proper units., if you have this information. (iii) You can either enter your best estimate of the percent of the tank volume that is taken up by liquid as % Full By Volume, or you can use the scroll bar next to the tank diagram to indicate the approximate height of the liquid level in the tank. Scroll up or down to position the horizontal bar on the diagram to indicate the liquid height. For this case, enter 100,000 pounds.*

To determine a liquid level, you could, if possible, check for a condensation line on the outer tank wall to get an estimate of the liquid level within the tank.

3e) Gas in Tank - Whenever you indicate to ALOHA that a tank contains only gas, you are asked to identify either the tank pressure or the amount of gas in the tank.

> *Instructor demonstrates methods of indicating gas volume:*
> *Type in a value for either (i) the tank pressure or (ii) the amount of gas. If you enter a value for tank pressure, ALOHA will automatically calculate the mass in the tank. You can specify the amount of gas either directly as a mass, such as 1 ton, or as a volume at standard temperature and pressure. Then click OK.*

Once you have entered values for tank size, temperature, and either pressure or amount of chemical, ALOHA will check to be sure that the chemical is a gas. If the tank temperature is below the chemical's normal boiling point, or if the tank pressure is high enough to liquefy the chemical, ALOHA will warn you that your chemical is not a gas. If this happens, click Cancel to return to the previous screen, click Tank Contains Liquid, then continue.

3f) Hole in Tank - *Instructor demonstrates methods of indicating hole characteristics:*

> *1) Indicate the shape (rectangular or circular) and size of the opening in the tank before ALOHA can calculate the rate of release of the tank's contents.*

2) Specify whether the release is through (i) a hole - when the chemical is escaping through an opening directly in the tank wall, or (ii) short pipe/valve - when the chemical is escaping through an open relief valve, broken valve, or any kind of short pipe or tube extending at least 10 centimeters (4 inches) from the wall of the tank. For this case, enter 3 inches.

The area of an opening is important to ALOHA, but its shape is used only to compute area. ALOHA predicts identical release rates through circular and rectangular openings, if they have the same area.

If the chemical is stored as a pressurized liquid (a liquid at a temperature above its boiling point), ALOHA may expect it to escape from the tank under pressure as a mixture of gas and liquid ("two-phase flow"). In pressurized liquid release cases, your choice of hole type can have an important effect on ALOHA's release rate computations because ALOHA accounts for the friction generated as the gas/liquid mixture passes through a constricted passage such as a valve or short pipe. ALOHA will predict a HIGHER RELEASE RATE for a two-phase release if you choose the hole option rather than the short pipe/valve option. Hole type does not make a difference in a pure gas or unpressurized liquid release case.

3g) Leak Height on Tank - If there is liquid in the tank, you must tell ALOHA where the leak occurs on the tank. You need to enter a value for the height of the bottom of the leak (whether it is a hole, pipe, or valve) above the floor of the tank. ALOHA uses this value to determine whether the leak is above or below the liquid level. If an unpressurized liquid is stored in the tank and the leak is below the liquid level, the chemical will spill out and form a puddle on the ground. It will stop spilling once the liquid level falls below the bottom of the leak. If the leak is above the liquid level and an unpressurized liquid is stored in the tank, ALOHA will report that no chemical is released. Regardless of the height of the leak, however, if the stored chemical is a pressurized liquid, it will escape through the leak directly into the atmosphere (without forming a puddle) as a two phase flow of gas and aerosol (fine liquid droplets).

Instructor demonstrates

1) Indicate the height of the leak above the tank bottom by either entering the height of the leak in distance units, specifying the leak location as a percentage of the total distance from the bottom to the top of the tank (for example, "60%" means that the leak is 60% of the way to the top of the tank), or using the scroll bar to the right of the tank diagram to indicate the height of the leak on the tank wall. Enter 60%
2) If the chemical is stored as a non-pressurized liquid, a puddle may be formed, and ALOHA will ask you for information about the area where the puddle will form. You will need to enter ground type and ground temperature, just as you would if you had selected the Puddle source option discussed earlier.
3) Run footprint and comment.

<u>Student Hands on Work</u>

[Instructor should now show slide entitled ‘Hands on Exercise (SetUp menu) and tell students to enter the tank release data as the instructor enters the data. Then, briefly instructor and students look at options submenu under display menu to confirm level of concern. Then, run footprint and note distance.]

PowerPoint Slide #51

Now consider liquid hydrogen fluoride leak from a tank at the same refinery. A tank with a 10 foot diameter and a 25 foot length stores 100,000 pounds of hydrogen fluoride. The tank has a 3 inch hole 60% up from the bottom.

What is the distance of IDLH? Was the office building affected by the release?
(Walk through data entry, display footprint and concentration graph)

4) Pipe
Now that we completed the tank option, let's look at the pipe option. This option models the release of gas from a leaking gas pipeline.

4a) Types You can model two types of gas pipeline leak scenarios:

- a pipeline connected to a very large or infinite reservoir so that gas escapes from the broken end of the pipeline at a constant rate for an indefinite period of time.

- a limited length or section of pipe that is closed off at the unbroken end by something like a shut-off valve. Because pressure within this section of pipe declines as gas is released, release rate drops over time and the release continues only until the section of pipe is emptied.
- ALOHA cannot model gas releases from a pipe that has broken in the middle and is leaking from both broken ends.

Instructor choose infinite reservoir.

<u>What will happen if we select the pipe option with benzene?</u> The pipe must contain only gas; ALOHA cannot model the release of liquid from a pipe. To describe a pipe release to ALOHA, you must enter the pipe diameter and length, and indicate whether the pipe is connected to a reservoir. You must also determine whether the inner surface of the pipe is rough or smooth. A "rough" pipe would be, for example, a metal pipe with a rusted inner surface or a pipe that has been corroded on the inside by the chemicals it carries. A "smooth" pipe would be, for example, a new metal pipe, glass pipe or plastic pipe.

On the next input screen, pipe pressure, temperature, and hole size are requested. Each of these affect the rate of release.

4b) Pipe pressure - If the pipeline is connected to a very large ("infinite") reservoir, you should use the pressure within the reservoir as your value for pipe pressure. If gas is escaping from a finite, closed-off section of pipeline, you should enter the pressure within that pipe section.

Instructor enter sample reservoir pressure.

4c) Pipe Temperature - Then you need to enter the temperature of the pipe by either clicking on Unknown, which assumes ambient temperature or typing in a specific temperature. If unknown is selected, ALOHA will assume the pipe temperature is the ambient air temperature.

Instructor select unknown temperature.

4d) Hole Size - If only a finite length of the pipeline is leaking, you can choose to (a) enter a value for the area of the hole, or (b) allow ALOHA to use the pipe diameter as its value for the hole diameter. If you know the diameter of the pipe hole but not its area, divide the diameter in half to obtain the radius, square the radius, then multiply it by pi, 3.14, to obtain the area. If the diameter is in units of feet, then the area will be in units of square feet.

Model assumes pipe sheared off; no need to enter value.

If the pipeline is connected to a very large ("infinite") reservoir, ALOHA assumes that the pipe has been completely sheared-off, so that the hole diameter equals the pipe diameter.

Script Notes for Session VIII

Day 1

VIII. ALOHA Display Menu: Level of Concern and Display Results Submenus (3:30-4:30 p.m.)

Learning Objectives: Through an instructor demonstration and some student hands on work, the students will gain a perspective on the relevant modeling issues in choosing a Level of Concern (LOC) to use and run the model properly. At the end of this session, the class will be able to:

Options Submenu

- Choose an appropriate LOC (discuss issues with LOCs)
  Discuss LOC and use of concentration
  - *From the Display menu, select Options and then enter value to change the LOC*
- Contact duration
  - *Select concentration from the Display menu*

Footprint, Concentration, Source Strength Submenus

- Display footprint of an ALOHA calculation
  - *Select footprint from the Display menu*
  Interpreting a footprint
- Display concentration graph
  - *Select concentration from the Display menu*
  Choosing coordinates
  Using fixed (east-west and north-south) coordinates
  Interpret a concentration graph
  Designating a location for concentration measurement
- Building type and indoor infiltration
- Display Source Strength
  - *From the SetUp menu, select Source*

Detailed Script for Session VIII- 1st Day

3:30-4:30 p.m. Session VIII Display Menu: Level of Concern (1) and Display Results (2) Submenus

1) Choose an appropriate Level of Concern (LOC)

As was discussed in the air dispersion section, the LOC selected in ALOHA affects the footprint, sometimes dramatically. While the default LOC in ALOHA is the IDLH, the user may select another LOC corresponding to a different type and/or less severe hazard. A lower LOC will increase the size of the footprint.

Always keep in mind that the footprint is a ballpark estimate and there is also uncertainty in any selected LOC. The footprint is therefore never an exact map of the hazard zone for a particular incident.

1a) Level of Concern

An IDLH or other level of concern value may change over time due to a new study or better information. For example, the ammonia IDLH was recently lowered from 500 to 300 ppm. To help you use ALOHA to update chemical information, we will modify an LOC (in this case an IDLH),

Under the SetUp menu, click on chemical to show list of chemicals
Type AMM to select ammonia
Click on Modify and then select IDLH
In this example, change the value from 300 to 200 ppm
Click OK to temporarily change the value

When changing an LOC, be careful to choose correct units. The value needs to conform to units that ALOHA can accept. An example of another LOC would be a TLV-STEL value, which is usually expressed in ppm. Depending upon the user's LOC, a unit conversion may need to be performed. For example, an explosive or flammability limit, in most data sources, is expressed as a percentage by volume of a vapor in air. To convert percentage by volume to ppm, just multiply the percentage value by 10,000 (1% of a million is 10,000, so 10,000 ppm is equal to 1%). Other LOCs may require more simple conversions such as *grams* per cubic meter or *pounds* per cubic *foot* to milligrams per cubic meter (mg/m^3).

1b) Account for contact duration

In selecting a LOC, the user in most cases needs to consider the exposure duration. How badly a person is affected by a chemical depends for the most part on how long the contact lasted and how high the concentration was during that time. For this reason, most LOCs have a contact duration associated with them. The contact duration associated with a LOC is part of the definition of that LOC. For example, the contact duration for TLV-STEL is 15 minutes. IDLH is an exception; it does not have a contact duration associated with it although in the past, it had a contact duration of 30 minutes.

The contact duration is important when reviewing ALOHA output. After a chemical release, at any point downwind where the chemical cloud passes, the concentration will rise and fall over time. This change in concentration over time can be viewed in ALOHA by looking at the **Concentration vs. Time** graph for a location. This graph can be used to account for the LOC's contact duration. Within the footprint, select a point and display the graph. Then check the graph to determine how long the LOC is exceeded at this point and other locations. If the LOC is exceeded for longer than the LOC's contact duration at a location, this location is considered to be in the predicted hazard zone. There may be cases where ALOHA predicts the LOC is greatly exceeded at a particular location, but for a time period shorter than the LOC's contact duration.

> *Ask students: Does this mean that the chemical poses no hazard? No. For instance, if the concentration is high enough to be lethal within the timespan, it most certainly poses a hazard.*

2) Display footprint of an ALOHA calculation

> *Select footprint from the Display menu*

Interpret the footprint. To show how much the cloud's position could change if the wind were to shift direction, under the particular weather conditions that you enter, ALOHA draws two dashed lines, one along each side of the footprint. ALOHA predicts that about 95 percent of the time, the wind will not shift direction enough to blow the pollutant cloud outside of either line. The wider the zone between the lines, the less predictable is the wind direction and the more likely it is to change substantially. At the lowest wind speeds acceptable to ALOHA (about 2 knots, or 1 meter per second, at a height of 3 meters), these lines form a circle to indicate that the wind could blow from any direction.

ALOHA predicts that average concentrations will be highest near the release point and along the centerline of any pollutant cloud, and will drop off smoothly and gradually in the downwind and crosswind directions.

3) Interpret an ALOHA concentration graph

In addition to examining the contact duration, the concentration graph is an important ALOHA output for analysis of a release. A concentration graph is useful whenever you're concerned not only about the extent of the whole area that might be at risk (i.e., the footprint) during a release, but also the hazard to specific locations such as schools or hospitals. The graph shows predicted chemical concentrations in indoor and outdoor air at ground level during the hour after a chemical release begins.

3a) Designating a location for concentration measurement

We will discuss two ways to select a location for a concentration measurement.

The first way is to double-click on any point in the Footprint window. This method is easy to perform but it can be difficult to select an exact location.

> *Click within a Footprint window*

The second method is to choose Concentration from the Display menu and then enter the coordinates. Coordinates can be fixed (east-west and north-south) or relative (downwind, crosswind). Again, pay attention to the units for distance.

Choose Concentration from the Display menu

In either case, ALOHA will display a Concentration window and graph on the graph. On the graph, the green line is labeled as the LOC. Again, the red line is the predicted outdoor concentration, while the purple dotted line is the predicted indoor concentration. Also note, ALOHA predicts the concentrations downwind of a release to be highest along the centerline of a dispersing pollutant cloud (where the crosswind distance is zero), so the centerline concentration will always be the most conservative concentration estimate for a location (meaning that by obtaining the centerline concentration, you are less likely to underestimate the potential concentration at a location).

3b) Building type and indoor infiltration

As can be seen in the Concentration window, ALOHA predicts the concentration outside a building to build up more rapidly than the indoor concentration. This is due to ALOHA accounting for a relatively slow rate of infiltration into buildings and its assumption that doors and windows are closed. ALOHA expects pollutant gas concentrations to build up faster within single-storied than double-storied buildings and within unsheltered than sheltered buildings. For single-and double-storied buildings, ALOHA accounts for the effects of wind speed and temperature to compute air exchange rates. ALOHA expects a building's air exchange rate to increase if the wind speed increases, because a faster wind exerts more force to push air through the small openings in a building's walls. Also, the greater the temperature difference between indoor and outdoor air, the higher the air exchange rate, regardless of whether the air within the building is warmer or cooler than the outside air (this is due to pressure: air masses of different temperatures have different pressures, and pressure difference stimulates air movement). The higher a building's air exchange rate, the faster the concentration of a toxic gas is predicted to rise within a building.

4) Source Strength

The source strength is the rate of release of a chemical into the air. A chemical may escape into the atmosphere very quickly (a high source strength), as when a pressurized container is ruptured, or more slowly over a longer period of time (a low source strength), as when a puddle evaporates.

Go to the SetUp menu and select Source

As seen in the menu selections, ALOHA can model four types of sources: Direct, Puddle, Tank, and Pipe. Direct is chosen when you know the rate at which a pollutant gas is entering directly into the atmosphere as well as the duration of the release. Choose Puddle when the chemical has formed a liquid pool and is evaporating into the atmosphere. Tank is chosen when the chemical is escaping from a storage tank, either as a gas or as a pressurized or unpressurized liquid. Finally, choose pipe when the chemical is a pressurized gas escaping from a ruptured gas pipeline.

ALOHA expects a release to continue for at least 1 minute and go for no more than 1 hour. ALOHA will not allow entering a value outside of this range. A reason for the 1-hour duration limit is that the wind changes speed and switches direction frequently. However, ALOHA assumes that weather conditions remain constant for the duration of a release. When release conditions change, it is important to enter updated data into ALOHA and rerun the scenario.

Script Notes for Sessions IX and X

Day 1

IX. Hands On Running of ALOHA (4:30-4:45 p.m.)

Learning Objectives: Student will run the ALOHA model with one predefined scenario. At the end of this session, the class know how to run ALOHA.

Scenario:

- Release occurs at a Publicly Owned Treatment Works (POTW) at 7 am on May 23, 1996 in Houston, Texas
- One building of concern is a one story schoolhouse a kilometer away with unsheltered surroundings (meaning no trees or shrubs)
- Chemical released is chlorine.
- Atmospheric data: wind is east at 2 meters / sec (measured from 3 meters above ground), clear skies, 50% humidity, 65^{o}F, and flat topography (open country).
- Release scenario data includes 1 inch diameter hole from bottom of a 10 foot diameter by 20 feet long horizontal tank pressured at 14 atm. The tank contains 65 tons of liquid chlorine.
- What is the potential footprint distance in kilometers?
- Will air in schoolhouse be over the IDLH concentration for chlorine?

Work Through Solution

X. Questions and Answers (4:45-5:00 p.m.)

Although the trainer should allow the class to ask questions as they arise during the day, a short period will be set aside for questions at the end of the day. This session can be extended is necessary over the allotted fifteen minutes. At the end of the Q&A session, the trainer should give a brief summary of the topics to be covered in the next day, and remind the students when class will begin the following day.

Detailed Script for Session IX · 1st Day

4:30 - 4:45 p.m. Session IX Hands-On Running of ALOHA

PowerPoint Slide #52

Here are the scenario assumptions. Go ahead and input them into ALOHA. Note that the wind was measured 3 meters above ground and the schoolhouse has unsheltered surroundings, meaning no trees or bushes.

Instructor: Allow time for students to run the scenario and then ask the following questions:
- What is the potential footprint distance in kilometers?
About 3.5 miles or 5.64 kilometers.
- Will air <u>in</u> the schoolhouse be over the IDLH concentration for chlorine? Yes, after about 20 minutes. This is determined by selecting Concentration from the Display menu. Input 1 km as X, the downwind distance and 0 as Y, the crosswind distance. The purple dotted line shows that the predicted indoor concentration rises above the level of concern of 10 ppm approximately 20 minutes after the release begins.

Script Notes for Sessions I and II

Day 2

I. Short Reintroduction to ALOHA Model (8:30-8:35 a.m.)

- Covered Yesterday
- Cover Today

II. Hands On Running of ALOHA (8:35-9:20 a.m.)

Learning Objectives: Students will run the ALOHA model to identify major issues, problems and caveats, and recommendations for the two given scenarios. The scenarios are in the student workbook.

Detailed Script for Sessions I and II • 2nd Day

8:30 - 9:20 a.m. Sessions I and II Reintroduction and Hands-On Running of ALOHA

PowerPoint Slide #53

Welcome and get ready for the 2nd day of ALOHA training. Yesterday we covered an introduction to ALOHA, a scenario demonstration, air dispersion, ALOHA menus, and then conducted a hands on running of ALOHA.

PowerPoint Slide #54

Today, we have a full schedule. In the morning we will conduct a hands on running of ALOHA, look at the effect of inputs on outputs, discuss proper use of ALOHA and look at example cases, and then discuss tools and tips for running ALOHA. In the afternoon, we will look at using ALOHA for mapping and meeting Federal Requirements, go over exercises and a scavenger hunt, and we will finish the course with a MINI-Test and a course wrap-up.

PowerPoint Slide #55

1. On October 9, 1996 at 2:30 PM, a work crew finds a 2" hole in the side of a 12,000-gallon vertical butane tank. The tank is located in a remote facility outside of Provo, Utah, where large amounts of liquid butane are stored. The crew reports that the hole is about 2" from the bottom of the tank. The tank diameter is about 10' and at the time of the leak, the tank was 70 percent full. The tank itself is surrounded by a cement platform and, further away, the terrain is mostly barren.

The following on-scene weather observations were taken by the work crew at 2:30 PM: the cloud cover is about 1/10 with winds from the ENE at 12 knots. The air temperature is 56°F with a relative humidty of 34 percent.

Assuming that the LOC is 800 ppm, what is the downwind distance?

- What happens if you change ground roughness to urban?
- What if you change the LOC to 80 ppm?
- What happens if the source strength doubles?
- What happens to footprint with you change stability to F?

Show results of changes in table and briefly discuss them.

PowerPoint Slide #56

Here are the results of modeling the butane release. If you run the release as written with the original inputs, the footprint distance is approximately 330 yards. The distances are rounded to the closest 10 yards because the ALOHA results are estimates and not precise numbers. The results in the other columns present the footprint distances if you change the surface roughness to urban, if you change the level of concern to 80 ppm, if you double the source strength, and if you change the stability to F. Note that the most significant changes to the footprint distances were as a result of changing the level of concern and changing the stability. With a change of the level of concern from 800 to 80 ppm, the distance more than triples. With a change of stability from D to F, the footprint increases by over 50%. For those of you who were struggling with determining what the hole diameter should be to double the release rate, the answer is found in knowing that the diameter is two times the radius and in using the equation that hole area equals pi times the radius squared.

PowerPoint Slide #57

Let students enter the data from the following scenario. While they are doing this, ask them what release source they used, tank or direct. Indicate that we have an release amount and duration, so a direct source can be used.

2. On March 17, 1995 at 4:15 AM a chemical release occurs at some garden or hardware facility on Alvey Dr. in Prince William County. As part of an accident investigation, the fire department determines that 15 tons of anhydrous ammonia were released in about 30 minutes from a leak at the bottom of a tank. The horizontal tank has a 10-foot diameter and is 25 feet long. There is a 6" valve on the bottom of the tank. The anhydrous ammonia was stored at ambient temperature.

The investigation team reports that the terrain around the facility is mostly flat grassland, but they have noted several small foothills about one mile north of the facility.

During the response effort, no on-scene weather observations were recorded. However, the investigation team collected observations from an airport 5 miles away from the accident. At the time of the accident, the wind was from the north at 5 knots. The air temperature was 52^{o}F and the relative humidity was 58%. The barometric pressure 30.25 inches and the sky was clear. For the purposes of entering the new location in ALOHA, Prince William County is located near Fairfax, Virginia (a city already listed in ALOHA).

The facility manager insists that a small, circular hole in the bottom of the tank resulted in the leak, although a careless employee might have left the valve open. A farmer 0.25 miles to the south says his cows are acting sick. What is the distance of the LOC?

The distance to the LOC is about 1.25 miles.

Script Notes for Session III

Day 2

III. Effects of Inputs on Outputs (9:20-9:40 a.m.)

- Play game where you give input that is increasing and the students must answer if footprint is longer or shorter and why.

Detailed Script for Session III · 2nd Day

9:20 - 9:40 a.m. Session III Effects of Inputs on Outputs

PowerPoint Slide #58

Let's play a game. All of these inputs affect the footprint length. If you increased these inputs, what happens to the footprint? You tell me if it gets shorter or longer. {mention input and let class say shorter and longer and ask why if right or wrong} Answers are:

In the case of a release to the air, the distance is shorter because an increase in wind increases dispersion and dilution of the vapor cloud.

wind.....shorter. However, if the release is from a puddle, the situation is more complex. A puddle will evaporate at a faster rate with large wind but at the same time, the larger vapor cloud will disperse and dilute faster under the same large wind. The ultimate result is not clear with a puddle.
stability.... longer
roughness.... shorter
LOC.... shorter
release rate... longer
release duration... longer contact time (and sometimes longer footprint as well, depending on the scenario). However, this is not always true.

PowerPoint Slide #59

{continue game with these inputs}Answers are:
puddle area... longer
puddle temperature... longer
air or ground temperature...longer, only if a puddle is formed. The temperature will increase evaporation of the chemical and make the footprint longer.
solar radiation... longer
rupture size...longer
vessel pressure... longer
vessel temperature... longer
air exchange rate... faster buildup of indoor concentration, faster cleaning out

Now, if the chemical is a gas and its molecular weight is greater than that of air, would ALOHA always expect it to disperse as a heavy gas? Well, the answer is no. Demonstrate. Choose a heavier than air gas like phosgene, released at 30 pounds/hour under D stability. Run the footprint and the results indicate that the heavy gas model was used. Now change the release to 30 grams/hour and the results indicate that the Gaussian or neutrally buoyant algorithm was used. The difference is that the second release rate is so much smaller that the concentration of pollutant gas is not sufficient to cause heavy gas behavior.

Script Notes for Session IV

Day 2

IV. When and When Not to Use ALOHA (9:40-10:10 a.m.)

Discuss times to use caution when running ALOHA

Very low wind speeds
Very stable atmospheric conditions
Wind shifts and terrain steering effects
Concentration patchiness

Discuss effects that ALOHA does not account for:

Fires or chemical reactions
Particulates
Solutions and mixtures
Terrain

BREAK (10:10-10:25 a.m.)

Detailed Script for Session IV

9:40 - 10:10 a.m. When and When Not to Use ALOHA

PowerPoint Slide #60

One of the most important things to get out of this training is to know when and when not to use ALOHA. Just quickly running ALOHA because it is easy to use without deciding if it should be used is inappropriate and can even be dangerous.

In addition to this session, there are some guidance materials to help you decide if running ALOHA is appropriate. In your student manual is a document called ALOHA Decision Keys. The ALOHA Decision Keys guides you with step by step questions to find out whether it is appropriate to run a particular scenario using ALOHA.

During the next 45 minutes, we are going to discuss:

- When you should use particular caution in interpreting ALOHA's results
- Various effects that ALOHA can not account for

First, let's start with four situations when it is important to interpret ALOHA's output cautiously.

PowerPoint Slide #61

As long as wind direction does not change, ALOHA's footprint represents a pollutant cloud's location. However, wind direction is least predictable when wind speed is low. ALOHA tries to address this by drawing two dashed lines, one along each side of the footprint. These lines represent the ALOHA prediction that about 95 percent of the time, the wind will not shift direction enough to steadily blow the pollutant cloud outside of either line. The wider the zone between the lines, the less predictable is the wind direction and the more likely it is to change substantially. At the lowest wind speeds acceptable to ALOHA, these lines form a circle to indicate that the wind could blow from any direction.

A note to the instructor: ALOHA does not accept wind speeds lower than 1 meter per second (about 2 knots) at 10 meters height. However, because ALOHA accounts for the effects of the wind profile, it often accepts wind speeds of less than 1 meter per second at heights below 10 meters (what it does is estimate from your entered value what the wind speed would be at 10 meters; it accepts your value if the 10-meter speed is at least 1 meter per second).

PowerPoint Slide #62

As you remember from the talk on air dispersion, under the most stable atmospheric conditions, like F stability, there is usually very little wind and almost no mixing of the pollutant cloud with the surrounding air. This is especially true for heavy gases under very stable conditions. The cloud spreads slowly, and high gas concentrations may build up in valleys or depressions. Most dispersion models, including ALOHA, have difficulty with these stable conditions. This is what happened in the accidental release of methyl isocyanate gas at Bhopal, India in 1984 when thousands of people died. ALOHA does not account for buildup of high gas concentrations in low-lying areas.

PowerPoint Slide #63

During a release, winds can shift and move a cloud where you don't expect it. This may happen especially as the winds flow up or down slopes, between hills or down into valleys, turning where terrain features turn. However, ALOHA assumes that wind speed and direction are constant throughout the area downwind of a chemical release. ALOHA also ignores terrain steering effects and assumes that the ground below a dispersing cloud is flat and free of obstacles.

In part, because the wind is likely to shift in direction and change speed over both distance and time, limits have been placed on ALOHA’s output. ALOHA will not make predictions for more than an hour after a release begins, or for distances more than 10 kilometers from the release point.

PowerPoint Slide #64

No one can predict gas concentrations at any particular instant downwind of a release with certainty, because they result partly from random chance. Particularly near the release source, gas concentrations at any moment can be high in one location and low in another because wind eddies push a cloud unpredictably about.

To address this concentration patchiness near the source, ALOHA predicts concentrations that represent averages for time periods of several minutes. ALOHA assumes the highest concentration is along the centerline of any pollutant cloud and will drop off smoothly and gradually in the downwind and crosswind directions.

PowerPoint Slide #65

ALOHA does not account for these effects:

Fires or chemical reactions - The smoke from a fire, because it has been heated, rises before it moves downwind. ALOHA doesn't account for this initial rise, nor does it account for the by-products of combustion. ALOHA assumes a chemical does not react when it disperses. However, many chemicals react with dry or humid air, water, other chemicals, or even themselves. Because of these chemical reactions, the chemical that disperses downwind might be very different from the chemical that originally escaped from containment. For example, hydrogen fluoride reacts with water vapor in the air, which creates heat and gives the gas buoyancy. For the products of these reactions, ALOHA's dispersion predictions may be inaccurate. ALOHA may warn you if you try to model a chemical that commonly may react with air and/or water vapor.

Particulates - ALOHA does not account for the effect of particulate matter on the dispersion of the chemical (i.e., dry deposition or settling).

Solutions and mixtures - ALOHA is designed to model the release and dispersion of pure chemicals only; the property information in its chemical library is not valid for chemicals in solution or for mixtures of chemicals. It's difficult for any model to correctly predict the behavior of a solution or a mixture of chemicals because it's difficult to accurately predict chemical properties such as vapor pressure for solutions or mixtures. When incorrect property values are used in ALOHA, the model's release rate and dispersion estimates will not be valid.

Terrain - In terms of terrain, ALOHA expects the ground below a leaking tank or puddle is flat, so that the liquid spreads out evenly in all directions. It does not account for pooling within depressions or the flow of liquid across sloping ground.

Please take all ALOHA warnings seriously. Don’t use ALOHA when these effects are present. For emergency response, instead rely on your own observations, your own experience and judgment, and other information about the escaping pollutant.

Script Notes for Session V

Day 2

V. Case Histories: Problem and Success Stories (10:25-11:10 a.m.)

Successes

- Hydrogen fluoride
- Chemical Reaction

Problems

- Indoor release
- Refrigerated Chemical
- Release of Mixture

Take Home Points

Detailed Script for Session V, 2nd Day

10:25 - 11:10 a.m. Case Histories: Problem and Success Stories

PowerPoint Slide #66

If your model isn't designed to handle a particular accident scenario, or if you can't obtain good values for the inputs that your model needs, your model results for planning or response may not be worthwhile or may even be dangerous. Over the years, ALOHA has been put to use by responders and planners around the world as well as in the U.S. What problems have people experienced when they used ALOHA? What successes have they had? Here are some real-life case histories. All are examples of people using ALOHA for response or planning applications. In some of these cases, ALOHA proved to be a valuable tool for its users. In other cases, people encountered problems when they tried to use it. We'll identify some of the reasons why some people were successful ALOHA users and others weren't.

PowerPoint Slide #67

Here is a successful example of ALOHA use. A railroad tank car filled with hydrogen fluoride derailed on the outskirts of Louisville, Kentucky. Before preparing to move the tank car back onto the tracks – an operation that could result in rupturing or puncturing it – a hazards coordinator for Louisville and Jefferson Counties used ALOHA to model a potential hydrogen fluoride release. An initial concern was that if the tank car ruptured, the hydrogen fluoride would escape as a two-phase flow. Such a heavy, dense cloud of pressurized gas and aerosol droplets is the most dangerous kind of release because, depending on conditions, concentrations may remain high within such a cloud for distances far downwind of the point of release. However, once he entered weather and source strength information, ALOHA quickly showed that on this cool morning in early November, the hydrogen fluoride, stored at the ambient temperature of 50ºF, was well below its boiling point of 67ºF. It would escape from the tank car not as a two-phase flow, but as an unpressurized liquid. This result alerted responders to expect a puddle of hydrogen fluoride to form in the event of a rupture and to consider diking as a response option – an alternative they might otherwise have overlooked.

PowerPoint Slide #68

Sodium hypochlorite is used at a sewage treatment plant. Both sodium hypochlorite solution, a water purifier, and sulfuric acid, which is used to adjust pH, are stored at a sewage treatment plant. These two chemicals, if mixed, will react violently to produce chlorine gas.

An environmental consultant used ALOHA to estimate how much sodium hypochlorite could be stored at the plant without creating a significant chlorine exposure hazard to residents living beyond the plant's fenceline. To do this, he made the conservative assumption that all the sodium hypochlorite would react with the sulfuric acid to produce the maximum possible amount of chlorine. He used basic stoichiometry (a method that allows you to estimate the quantities of constituents involved in a chemical reaction) to estimate how much chlorine would be evolved from the reaction of a given amount of sodium hypochlorite with an unlimited amount of sulfuric acid. He assumed that the reaction, because it is violent, would last for just a few minutes. He then modeled the resulting chlorine release in ALOHA by entering worst-case weather conditions, then choosing the Direct source option, entering the amount of chlorine evolved from the reaction, and indicating that the release would be instantaneous. For his level of concern, he chose chlorine's Emergency Response Planning Guideline-2 (ERPG-2), an exposure limit that is more applicable for general populations (in contrast, the immediately dangerous to life and health, or IDLH, values in ALOHA's chemical library are more applicable for healthy adult workers). He obtained footprints for a range of amounts of sodium hypochlorite that could react with sulfuric acid without producing a chlorine footprint longer than the distance to the fenceline.

PowerPoint Slide #69

Police officers investigating reports of an illegal drug laboratory found that a mixture of volatile liquids had spilled from broken containers and pooled at the bottom of an apartment building stairwell. One officer tried to use ALOHA to predict the dispersion of evaporating vapors within the building. However, ALOHA could not make useful predictions for this incident because it isn't designed to model indoor releases. Like other air dispersion models, it accounts for the large-scale processes that move and disperse vapor clouds within a turbulent atmosphere. The processes that disperse vapors in the much less turbulent air within a building are very different, and ALOHA does not account for them.

PowerPoint Slide #70

During a practice drill, an emergency responder tried to model the release of refrigerated ammonia from a broken pipe connected to a storage tank. The user selected ALOHA's "Pipe" source option, which is designed to model releases of pressurized gases from pipelines. However, refrigerated ammonia is liquid, not gas. This user needed to choose a different source option – ALOHA's "Tank" option – for this release.

PowerPoint Slide #71

A tank car filled with oleum was being heated so that it could be off-loaded. When a safety valve blew out, a cloud of hazardous vapor escaped. Emergency responders tried to use ALOHA to model this accident, but quickly discovered that oleum is not included in ALOHA's chemical property library. This common substance was left out of the library because it is a mixture of two chemicals, sulfuric acid and sulfur trioxide. ALOHA can model the dispersion of pure chemicals only, so its chemical library does not include any mixtures or solutions. Not recognizing that a substance is a mixture or solution rather than a pure chemical or not recognizing that ALOHA can model pure chemicals only are common errors made by ALOHA users.

PowerPoint Slide #72

An air dispersion model like ALOHA can be a great help to you when you need to respond to an accidental hazardous chemical release or to plan for a potential accident. But these case histories show that whether or not ALOHA is a useful tool can depend on the skill of its user. People are most successful when they:

· **recognize ALOHA's main limitations**. Not recognizing ALOHA's limitations is one of the most common mistakes made by users. In some of these examples, people did not recognize that ALOHA can't model indoor releases or mixtures

· **have some understanding of the chemical being modeled**. ALOHA's most successful users typically have had at least some chemistry training and know that it's important to find out as much as you can about the chemical you're trying to model.

· **have practiced with ALOHA and understand basic air modeling concepts.** Although ALOHA is relatively easy to use, the science behind it is difficult to master. For that reason, as the people in some of these case histories discovered, it's not hard to make errors when you use ALOHA. The best way to ensure that you use the model safely and effectively is to practice with it as often as you can and to become as familiar with the basics of air modeling.

Script Notes for Session VI

Day 2

VI. Tools and More Tips for Running ALOHA (11:10-11:55 a.m.)

Tools

- Student Workbook
- ALOHA manual
- Dr. ALOHA columns
- User Groups
- ALOHA Decision Keys
    - Walk through Source Decision Tree
    - Give scenarios and have student make decisions

Tips

- Interpreting ALOHA's Lady Bug Lines
- Handling Two-Phase Releases

LUNCH BREAK (11:55-1:10 p.m.)

Detailed Script for Session VI • 2nd Day

11:10 - 11:55 a.m. Session VI Tools and More Tips for Running ALOHA

PowerPoint Slide #73

Aside from this course, there are other information sources available to help you decide if you are running ALOHA appropriately. These include the student workbook accompanying this course, the ALOHA manual that you should have, short articles called "Ask Dr. ALOHA" that provide pointed advice on common challenges and problems, and ALOHA Decision Keys. The ALOHA Decision Keys guides you with step by step questions to find out whether you can run a particular scenario in ALOHA, and if you can, what source option you should choose.

PowerPoint Slide #74

Here is one of the ALOHA Decision Keys that help you choose the source option that's right for the scenario. You follow the flow chart to choose between direct release option or tank, puddle, or pipe option.

Here is an example how you could use the source selection tool. It's high noon and 100°F and the only shade you can find is behind somebody's camel. You're out in the middle of the deserts of Saudi Arabia, helping a crack team of oil fire experts. On the way to an oil fire, the team encounters a pipeline leaking liquid acrolein. Should you choose the Pipe option to model this release in ALOHA? Why or why not?

Let's look at the chart.
Do we know the amount released? The answer is no.
Has a pool formed? The answer is yes.
Is liquid still leaking? The answer is yes.
Thus, we should use the tank option. We came to this conclusion, but why? The actual reason is that the pipe option is just for gas pipelines and this was a liquid release. To simulate a pipe, you might try modeling the release from a long, thin horizontal tank.

PowerPoint Slide #75

Each of these is a lesson in itself. I will cover these in a brief level of detail over the next 30 minutes.

PowerPoint Slide #76

Most emergency planners and responders are concerned with the furthest footprint distance, but planners and responders should also be concerned that the cloud could blow outside the darkened footprint zone because of the unpredictable wind direction. Consequently, ALOHA's footprint also displays lines outside of the footprint that look like a ladybug, hence the lines are called ladybug lines. What do you make of these ladybug lines? There is a Dr. ALOHA providing a detailed explanation of the ladybug lines but here is a short version. Wind direction is less predictable under unstable atmospheric conditions. To show you this, look at the top and bottom figures. The ladybug lines are much wider for the bottom figure. This figure represents unstable atmospheres under A stability when wind direction is less predictable. In fact, the footprint shows that the wind could shift so substantially that the footprint could rotate almost completely around in either direction. In contrast, the figure above represents stable atmospheres under F stability when wind direction is more predictable. The same sort of effects of narrow and wide ladybug lines occurs for low and high wind speeds. Under low wind speeds, the ladybug lines are similar to the bottom figure and may even be a circle. The demonstrates that slower wind are less predictable in direction than higher winds.

PowerPoint Slide #77

As you remember, two-phase releases are releases of gas and suspended liquid droplets called aerosol. Here is an example. During a warm summer day, a one-ton cylinder of liquid chlorine has a leak in a 2-inch valve. The release cloud is very dense and cold. Chlorine's boiling point is -29°F. Because the chlorine liquid is released at a temperature above its boiling point, the result is a two-phase release. When a two-phase mixture escapes from storage, the release rate can be significantly greater than that for a purely gaseous release.

When ALOHA predicts that the release will escape as a two-phase flow, it alerts you with a message on the Text Summary Screen: "Note: The chemical escaped as a mixture of gas and aerosol." It makes the conservative assumption that no liquid aerosol rains out of the cloud and falls to the ground. For pressurized liquids released well above their boiling points, as in this example, rainout is unlikely. In the chlorine example, the footprint is 1.7 miles. If the same release occurred in the bitter cold of Alaska below chlorine's boiling point of -29°F, the chlorine would instead form a pool and evaporate. The resulting dispersion distance would be only 0.5 miles compared to the 1.7 miles for the two- phase. The results differ dramatically. When modeling chemicals such as hydrogen fluoride, vinyl bromide, and acetaldehyde, that have boiling points close to ambient, be as accurate as you can when you estimate tank temperature. Your results from ALOHA can differ dramatically, depending on whether your estimate of tank temperature is above or below the boiling point of the stored chemical.

Be aware that ALOHA DOES NOT ACCOUNT FOR TWO-PHASE EFFECTS when you use the Direct source option to model releases of such heavier-than-air chemicals.

Script Notes for Session VII

Day 2

VII. ALOHA Use for Mapping and Meeting Federal Requirements (1:10-2:10 p.m.)

Learning Objectives: Instructor discusses mapping footprint through use of ALOHA with CAMEO and MARPLOT. Also, instructor describes how and when ALOHA can be used as a tool to support requirements of EPA's Risk Management Program Rule.

Mapping

- Introduce MARPLOT and CAMEO Sharing Menu
- Give general step-by-step instructions for displaying footprint on map
  Run a release scenario in ALOHA
  Open the map in MARPLOT
  Set the source point and plot the footprint
- Give general step-by-step instructions for determining concentrations for location on map
  Choose a Concentration point
- Show use of Search option to search for "objects that are inside of or touching the currently selected object." This can be used to select symbols for vulerable locations (such as schools and hospitals) within ALOHA's footprint or confidence lines. Get information, then bring up the CAMEO records for those locations.
- Compare use of ALOHA verses CAMEO's Screenings & Scenarios (e.g. sulfuric acid example where Screening may not be appropriate)
- Hands On Example Using ALOHA with CAMEO and MARPLOT

Meeting EPCRA Requirements

- Describe EPCRA
- Discuss how ALOHA can meet requirement and how it compares with Green Book

Meeting Risk Managment Program Requirements under the Clean Air Act

- Describe Risk Management Program
- Discuss how ALOHA can meet requirements and how it compares with Off-Site Consequence Analysis Guidance

BREAK (2:10-2:25 p.m.)

Detailed Script for Session VIII

1:10 - 2:10 p.m. Session VII ALOHA Use for Mapping and Meeting Federal Requirements

PowerPoint Slide #78

This session discusses how ALOHA footprints can be plotted on maps and how ALOHA can be used to meet Federal program requirements.

PowerPoint Slide #79

It's possible to plot an ALOHA footprint on a map. Maps are useful in assessing the relative risks presented by various chemical release scenarios and in planning response actions that may be necessary during actual emergencies. ALOHA works in coordination with a mapping application called MARPLOT. Both MARPLOT and ALOHA are components in CAMEO. Some of you may be familiar with CAMEO and MARPLOT. Basically, MARPLOT enables the user to create or use an existing map. Meanwhile, the footprint is created in ALOHA. To overlay the footprint on a map, you can switch between the ALOHA and MARPLOT applications through their "Sharing" menus. [show how this is done]

PowerPoint Slide #80

Here is a screen of the sharing menu in ALOHA.

PowerPoint Slide #81

The first step is to display a map in MARPLOT showing the area where a release has occurred. Then, you can switch to ALOHA to run a scenario and develop a footprint. Next, you can switch back to the map in MARPLOT to set the location of the release using the "Sharing Menu;" the ALOHA footprint will then be plotted on the map. The footprint will orient in the proper direction and size according to the map scale. Here, a school is contained in the footprint. MARPLOT also enables you to determine all of the receptors within the ALOHA footprint or confidence lines.

PowerPoint Slide #82

Besides looking at the footprint on the map, you may also want to find out the concentrations to which a person in the area might have been exposed. This might give the emergency responder a timeframe for alerting potential persons in the path of the pollutant cloud before it arrives. You can indicate a location on the map for which you would like to see ALOHA's concentration or dose concentrations. For example, you could see an ALOHA concentration graph for a school, hospital, nursing home, or other especially vulnerable population. By choosing Set Conc/Dose Point from the ALOHA submenu in MARPLOT's Sharing menu, you can get this ALOHA concentration graph.

PowerPoint Slide #83

ALOHA can be very useful for emergency planners or industry personnel who want to carry out offsite consequence analyses for the planning required by the Emergency Planning and Community Right-to-Know Act, or EPCRA. Under EPCRA, local emergency planners must develop emergency plans considering the presence of extremely hazardous substances, or EHSs.

ALOHA can also be used for conducting the hazard analysis required under section 112(r) of the Clean Air Act. EPA's Risk Management Program rule under section 112(r) of the Clean Air Act requires some facilities to conduct hazard assessments for processes with regulated substances, including offsite consequence analyses. Regulated facilities must model a worst-case release scenario, which has the potential to cause the greatest offsite consequences. Facilities also may have to model other release scenarios, called alternative scenarios. The worst-case and alternative scenario analyses must be reported in a risk management plan (RMP).

PowerPoint Slide #84

Under EPCRA, local emergency planning committees (LEPCs) must prepare emergency plans that include facilities with EHSs. Development of the plan should include a hazards analysis.

To assist planners in assessing the hazards of airborne releases of EHSs, EPA published a guidance document, *Technical Guidance for Hazards Analysis,* or the "Green Book." The Green Book provides methods to estimate release rates and lookup tables to determine dispersion distances. The Green Book calculations and tables are computerized in CAMEO under the Screenings & Scenarios module.

The Green Book guidance is not mandatory; planners can also use ALOHA or other models to model airborne releases of EHSs, if they choose, or do no modeling (by using the Green Book).

PowerPoint Slide #85

How do the Green Book and ALOHA results differ?

If you compare results from the Green Book with ALOHA modeling results, you will find some significant differences. For gases, the Green Book assumes release over a 10-minute period to determine the release rate. The Green Book method then calculates air dispersion distances assuming the release is continuous. When you model using ALOHA, you do not have to make the simplifying assumption that the release is continuous. Instead, with ALOHA, you can specify the release duration of 10 minutes as well as the release rate over a 10-minute period. ALOHA's capability to assume that the release stops after 10 minutes may result in substantially shorter distances than assuming the release is continuous.

For liquid releases, the Green Book uses a simple equation to determine the evaporation rate from a pool, whereas ALOHA takes into account effects such as changes in the evaporation rate resulting from changes in pool temperature from solar heating, evaporative cooling, or heat transfer with the air or ground. The Green Book and ALOHA results, therefore, may differ.

The lookup tables in the Green Book are based on Gaussian dispersion only. ALOHA uses Gaussian dispersion for substances that are neutrally buoyant and a heavy gas dispersion module for substances that are heavier than air. The heavy gas modeling result may be significantly different from the Gaussian results.

The lookup tables in the Green Book can be applied to any EHS, including solids and low volatility liquids. ALOHA, on the other hand, does not include solids and liquids with very low ambient vapor pressure in its chemical database.

The lookup tables in the Green Book cover a range of release rates and Levels of Concern (LOCs). You may not be able to use the exact release rate and LOC to determine dispersion distances. ALOHA, however, makes exact calculations of distances based on an exact release rate and LOC.

See "Ask Dr. ALOHA: Why is ALOHA Different from the Green Book?"

PowerPoint Slide #86

Some of you familiar with CAMEO may wonder what is the difference between CAMEO's Screenings & Scenarios module and ALOHA. As you can see, CAMEO's Screenings & Scenarios provides vulnerable zone that is somewhat like ALOHA's footprint. Lets compare the two.

PowerPoint Slide #87

What's the difference between an ALOHA footprint and the threat zone plotted by the Screenings & Scenarios module? The Screenings & Scenarios module makes the simplified threat zone calculations described in the EPA guidebook, <u>Technical Guidance for Hazards Analysis</u>, often called the "Green Book." It is intended for use as a screening tool for planners. In contrast, ALOHA makes a footprint estimate by taking into account many factors - such as additional properties of the chemical, weather conditions, and the specific characteristics of the release - that are not included in Screenings & Scenarios calculations. ALOHA calculations are more complex and often predict the effects of a particular release more accurately.

PowerPoint Slide #88

Facilities subject to the RMP rule must model worst-case release scenarios for processes with regulated substances. They also may have to model alternative release scenarios. Alternative scenario analysis may not be required for a process if the worst-case scenario shows no potential impact on the public.

Regulated substances for the RMP include 77 toxic substances and 63 flammable substances. Facilities may use any appropriate model or method, including ALOHA, to carry out the required consequence analyses, as long as they use the required assumptions. EPA has developed a draft guidance document, *RMP Offsite Consequence Analysis Guidance*, or OCA guidance, that includes methods for carrying out the required offsite consequence analyses and lookup tables for estimating consequence distances.

The rule specifies the assumptions that facilities must use for the analyses of the worst-case and alternative scenarios. For example, the rule specifies the endpoints for modeling, that the model used must appropriately account for gas density, and that urban or rural topography must be taken into account.

PowerPoint Slide #89

Regulated facilities can use ALOHA to model worst-case scenarios for toxic substances, using the required assumptions, and a variety of alternative scenarios. For the worst case scenario, facilities with multiple regulated toxic substances may have to determine what scenario has the greatest potential to cause offsite effects. Facilities might want to use ALOHA for initial screening to choose the appropriate worst-case scenario.

Planners or other interested parties might want to use ALOHA in reviewing offsite consequence analysis results reported by regulated sources. You could compare the ALOHA results with the reported results and possibly flag results that look questionable, for example, results showing a much smaller offsite impact. You could ask the submittors to explain their results. Of course, the explanation could simply be that different models sometimes produce very different results.

For more information, see “Ask Dr. ALOHA: Using ALOHA to perform a worst-case consequence analysis” and “Using ALOHA to perform an alternative consequence analysis.”

PowerPoint Slide #90

ALOHA can model releases of most of the toxic substances.

Using ALOHA for the worst-case scenario analysis is a simple process, because the assumptions you need are specified by the rule and you just have to enter them into the model along with the toxic chemical and the quantity released. You will have to specify the required endpoint level of concern in the RMP rule for many of the chemicals, because the ALOHA default level of concern is the IDLH, which may not be the endpoint specified in the RMP rule. ALOHA will determine the correct model (Gaussian or dense gas) for the chemical.

You can easily and quickly model a variety of scenarios with ALOHA that could be alternative scenarios for the RMP. For example, to model a leaking tank, you can specify a tank size and shape, the quantity of a chemical in the tank and its physical state and temperature, and the shape, size, and position of a hole in the tank or in a pipe or valve.

ALOHA will take into account flashing releases of gases liquefied under pressure -- that is, when the pressure is suddenly released, by vessel failure for example, then some of the liquid immediately vaporizes, taking with it fine liquid droplets.

You might identify a possible alternative scenario involving a very short release of a gas -- a sudden puff -- that would be stopped very quickly (in less than a minute) by a block valve, for example. If you can estimate the quantity released this way, ALOHA can give you the dispersion distance if you specify an instantaneous source.

Besides determining impact distances for the worst-case scenario for the RMP, facilities must report the residential population within this impact distance. They also must report the presence of (not the number of people in) locations where people might gather, such as schools, hospitals, parks, stores, and office buildings. The mapping capability with MARPLOT used together with ALOHA will show these locations. Specific types of environmental receptors within the impact distance also must be reported, including national or state parks and wildlife sanctuaries. ALOHA and MARPLOT will show these areas as well.

For more information see “Ask Dr. ALOHA: Using ALOHA to perform a worst-case consequence analysis” and “Using ALOHA to perform an alternative consequence analysis.”

PowerPoint Slide #91

You may run into problems in some cases when using ALOHA to model scenarios for the RMP. ALOHA cannot model the effects of explosions and fires, with one exception. You could use ALOHA to determine the distance at which a vapor cloud disperses to its lower flammable limit (LFL); that is, you would use the LFL as the endpoint. A vapor cloud can ignite and burn if the vapor is within its flammable limits. Under the RMP rule, a vapor cloud fire is an acceptable alternative scenario for a regulated flammable substance; however, the worst-case scenario for flammable substances has to be a vapor cloud explosion, which you can’t model with ALOHA.

Another problem with using ALOHA is that you may run into a distance limit, particularly for highly toxic gases and volatile liquids or large releases. ALOHA does not estimate distances greater than six miles (or 10 kilometers), and EPA expects worst-case results for the RMP to be more specific up to 25 miles. You may have to turn to the OCA Guidance lookup tables or other models, if the distance for a worst-case release exceeds ALOHA’s limits.

ALOHA does not allow you to consider the mitigating effects of an indoor release. You are allowed consider passive mitigation (including indoor releases) in the worst-case and alternative scenario analysis for the RMP. You could overcome this limitation, however, by modifying the release rate calculated in ALOHA to factor in this mitigation.

You may encounter certain limitations in using ALOHA to model scenarios involving solutions or other mixtures for the RMP. The list of regulated substances includes several common water solutions -- aqueous ammonia, hydrochloric acid, hydrofluoric acid, and nitric acid. ALOHA is set up to model only pure substances. You can, however, alter the chemical properties in ALOHA’s chemical data base to reflect the properties of the solution, rather than the pure chemical, and use these altered properties for the modeling. You would also have to consider that the concentration of the released solution would change as the regulated substance evaporates. You might have to do some iterative modeling steps. Mixtures of regulated substances (other than the solutions that are specifically listed) also would present a problem for modeling.

Limitations of ALOHA for RMP analysis are also discussed in “Ask Dr. ALOHA: Using ALOHA to perform a worst-case consequence analysis” and “Using ALOHA to perform an alternative consequence analysis.”

PowerPoint Slide #92

You will find some differences between results from ALOHA and EPA’s OCA Guidance. If you compare the lookup table distances in this guidance with the ALOHA results for the same release, you may find discrepancies, particularly for dense gases, even using the same assumptions. For the OCA guidance, EPA used the SLAB dense gas model, whereas ALOHA uses a simplified DEGADIS model. The distance results for dense gases should be reasonably close, however -- that is, within a factor of two or so. The distance results for neutrally buoyant gases should be very close.

The OCA guidance for estimating the evaporation rate from a liquid pool uses a simple equation to estimate the initial evaporation rate and assumes the rate remains constant until the pool disappears. ALOHA takes into account effects such as changes in evaporation rate resulting from changes in pool temperature from solar heating, evaporative cooling, or heat transfer with the air or ground.

As already stated, ALOHA does not give distance results greater than six miles (or 10 kilometers); the lookup tables in the OCA guidance go up to 25 miles.

The lookup tables in the OCA Guidance cover a range of release rates and endpoints. The exact release rate and endpoint for your scenario may not be in the table, so you may need to choose the closest values to estimate a distance. As discussed earlier, ALOHA makes exact calculations of distances for a given release rate and endpoint.

ALOHA, as a computer model, is more versatile than the OCA Guidance, and can model some scenarios that are not addressed in the Guidance, including flashing liquid releases and puff releases.

Script Notes for Session VIII

Day 2

VIII. Examples: Class Exercises and Scavenger Hunt (2:25-3:25 p.m.)

- Provide Four Different Examples (see student workbook, let class try them and go over them)
- Work through Dr. ALOHA's Scavenger Hunt problems

Detailed Script for Session VIII

2:25 - 3:25 P.m. Session VII Examples: Class Exercises and Scavenger Hunt

PowerPoint Slide #93

Have students run three ALOHA examples in the student workbook. Examples to run include the release in Phoenix, Indianapolis, and Albany. Also, as a group, have them answer questions in the Dr. ALOHA Scavenger Hunt. Answer any and all questions that come up on modeling.

Script Notes for Session IX

Day 2

IX. Conclusion: MINI-Test and Wrap-up (3:25-4:10 p.m.)

- MINI-Test and Answers
- Questions and Answers
- Conclusion

Detailed Script for Session IX - 2nd Day

3:25-4:10 p.m. Session IX Conclusion, MINI-Test and Wrap-up

During this session, instructor covers the MINI-Test, answers any questions, and provides a conclusion of the course.

PowerPoint Slide #94

An air dispersion model like ALOHA can be a great help to you when you need to respond to an accidental hazardous chemical release or to plan for a potential accident, but only if you know how to use it and when not to use it. The best way to ensure that you can use the model safely and effectively is to practice with it as often as you can, to know the limitations for ALOHA, to become familiar will the basics of air modeling, to consider taking an introductory chemistry class, and to have access to a chemical library.

Please answer the following questions to "test" your knowledge of ALOHA:

1. What is the IDLH of Ammonia?

300 ppm

2. True or False. The IDLH for Ammonia or any other chemical will not change over time.

False. Any toxicity guideline level used as a level of concern can be revised with new information or study results.

3. What generally would happen to a footprint distance if the level of concern for Ammonia was reduced by 1/2?

The footprint distance would be larger. However, it would not simply be larger by a factor of 2 because dispersion calculations have many factors with complex relationships.

4. You decide you would like to use a reference dose (RfD) as a level of concern. The RfD value for your chemical is 5 mg/kg-day. Will you have a problem entering this value?

Yes. The units are inappropriate and the value can not be used. ALOHA only accepts levels of concern with units of ppm or milligrams/cubic meter.

5. The distance to the level of concern is predicted to be 3 miles. Your in-laws live 3.5 miles away. a. What kind of recommendation will ALOHA give for evacuation? b. What should you say to your in-laws?

a. None. ALOHA does not provide recommendations for evacuation.

b. You should suggest they either leave the area or stay indoors without building ventilation as a precaution. They should do this even though they might not be exposed to the level of concern and be in immediate danger. ALOHA distances are not synonymous with safe distances.

6. Ammonia liquified under pressure is released at a temperature of 75^{o}F. Will it be a gas, liquid, or two-phase release?

Two-phased. Ammonia's boiling point is -28.17 ^{o}F. It will likely be a mixture of gas and fine liquid droplets (aerosols).

7. True or False. The only way to evaluate the concentration at a specific location is to select a location in the Footprint Window.

False. Relative or Fixed coordinates can also be selected from the Concentration selection under the Display menu.

8. A rupture occurs in a tank holding various acids, including hydrochloric and sulfuric acid. There is, however, no fire or chemical reaction. Is it proper to use ALOHA in this situation?

No. ALOHA does not incorporate effects of chemical mixtures.

9. How would you use ALOHA to calculate the impact distance of a methanol fire?

You can't; ALOHA does not handle fires.

10. Methanol is released, but does not explode or catch on fire. Can ALOHA be used at all to see if it could explode or catch on fire?

Yes. The LEL or LFL could be used as a level of concern. ALOHA could then determine if there is an explosion or fire hazard.

11. True or False. ALOHA's results are easier to generate and are therefore more accurate when the wind speeds are very low.

False. Caution should be used when interpreting results from modeling with very low wind speeds (as displayed in the Limitations window when first beginning ALOHA). The direction of slower winds are less predictable. Also, remember that ALOHA always gives ballpark estimates.

12. Why should you use caution when running ALOHA for releases in Hawaii?

The effects of terrain steering and wind shifts may be an issue in this and other environments with large hills or mountains.

13. During the night there is a release. In the morning, your co-worker runs ALOHA using the computer's internal clock and atmospheric stability B. Would you believe the results?

No. The actual time of the release was not used. Atmospheric stability B is very unstable; during the night, the atmosphere is usually very stable.

14. ALOHA would not allow me to select a source (pool, tank, pipe) because the choices are greyed out. What could be wrong?

You didn't select a chemical yet, and ALOHA can not develop a source term without chemical property information.

15. True or false. An inversion entraps a chemical and reduces the impact distance of the chemical.

False. An inversion does entrap a chemical, but it may actually extend the impact distance. This is because a chemical will not likely disperse above a specific inversion height.

16. True or false. Changing from F stability to A stability will decrease the footprint length.

True. Generally increasing the stability makes the footprint longer. F stability is much more stable than A.

17. Of the two categories of pollutant gases covered in ALOHA (neutrally buoyant gases and dense gases), which gives the greater distances and why?

Dense gas will likely give greater distances because the gas will hug the ground and not experience as much entrainment of air.

18. What are 3 reasons to use ALOHA versus CAMEO's Screenings & Scenarios?

1. ALOHA is more appropriate for emergency response. Screenings & Scenarios is intended to be used for planning.
2. ALOHA uses more site-specific and chemical-specific input factors and is often more accurate.
3. ALOHA can model dense gases.

19. What is the upper limit in estimating distances in ALOHA?

6 miles.

20. Can you use ALOHA to satisfy EPA's Risk Management Program requirements?

Yes, but ALOHA has limitations, including: can't model fires or explosions, has a 6-mile limit, can't account for indoor releases, and doesn't model solutions or mixtures.

21. I want to model a release at F stability and I have entered in the windspeed (1.5 m/s) and cloud covering (partly cloudy) associated with F stability. Why does it default to B stability? What can I do?

You are probably modeling a release at a time when F stability doesn’t usually exist. You can override this restriction if necessary.